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THE UNIVERSITY OF ALBERTA

PLANNING AS A COGNITIVE PROCESS: AN EMPIRICAL INVESTIGATION

by

© DONALD BASTIAAN HEEMSBERGEN

A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES AND RESEARCH

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submitted by DONALD BASTIAAN HEEMSBERGEN

in partial fulfilment of the requirements for the degree of Doctor of PHILOSOPHY

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ABSTRACT

An information integration approach was utilized in three studies as follows. In study one, an attempt was made to establish the relationship between coding and cognitive style, utilizing a battery of simultaneous-successive tests and the Group Embedded Figures Test of Witkin et. al (1971). Fifty first year students in two programs at a community college volunteered to perform these tasks. Correlational and Factor-analytic methods were used to produce a simple factor structure to account for the coding and cognitive style dimensions. Results confirmed expectations in that field independence as measured by the Group Embedded Figures Test did not define a factor distinct from simultaneous processing.

Study two was comprised of two phases. In the first phase, the relationship between planning and coding (simultaneous-successive synthesis) was examined. In the second phase a number of experimental interventions were built into the study to extend the theoretical foundations of the planning tasks. In each phase separate samples of sixty community college students volunteered as subjects.

In the first phase, a battery of planning and coding tasks were administered in an attempt to replicate previous findings. Correlational and Factor-analytic methods were performed on the two test batteries. Subsequent solutions established the existence of three factors, with the simultaneous-successive and planning tasks loading on different factors.

In the second phase, differences in performance between subjects scoring high and low on tasks measuring planning were examined. The

performance for both high and low groups was in accordance with predictions. In the Visual Search task subjects in the 'high group' demonstrated superior performance in terms of utilizing the strategy taught by the experimenter. Furthermore, these subjects appeared to reach relative asymptotic performance earlier than did subjects in the 'low group' across trials. In the Trail-Making task, high and low groups also demonstrated consistent differential performance, suggesting the presence or absence of the utilization of a strategy between the high and low planners.

In the third study, the problem solving behavior of good and poor 'planners' (60 adult subjects) as indexed by their scores on a Visual Search task was examined. Good 'planners' demonstrated superior performance on a complex problem-solving task (mastermind). A qualitative analysis of subjects' responses confirmed that poor 'planners' in contrast to good ones, engaged in superstitious behavior; placed a low value on the process of systematic reasoning; did not use feedback appropriately; and finally, showed an absence of facilitatory vocalization. It was concluded, that further systematic investigation aimed at isolating the specific processes involved in planning was required.

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CHAPTER I

INTRODUCTION

In the 20th century we have witnessed two major approaches to the study of cognition, the differential approach, and the information processing approach.

The differential approach investigated cognition by examining individual differences in performance on psychometric tests, and by utilizing correlational methods as a means of identifying and relating major abilities. The assumption being that cognitive ability differences underlie differences in individual performance. Both Binet and Terman developed tests of cognition by selecting tasks which identified differing levels of ability in children. The tasks were arranged in order of difficulty and in Binet's case distinguished mentally retarded children from normals, while Terman identified the cognitively gifted. On the other hand Spearman (1927), Thurstone (1931), and Guilford (1967), using correlational methods attempted to define the nature of cognitive abilities. Spearman's research demonstrated that the correlation between various tests could be accounted for by a single general ability (g). Thurstone (1927) and Guilford postulated that ability tests, measured several abilities (s) rather than a single ability (g). The differential approach has as its focus the study of cognitive abilities and mental structures, and assumes that individual differences in performance on cognitive tasks are due to differences in ability.

Das et. al (1979), Sternberg (1979), and Estes (1974), among others have argued that the notion of individual differences reflecting ability differences may apply to certain populations (mentally gifted

and retarded), but does not adequately explain differences of the majority of individuals who are within the normal range of ability. They have argued that an approach which examines the processes underlying abilities may provide a more adequate explanation of cognition.

The information processing approach therefore investigates and seeks to understand cognition by examining and emphasizing task differences reflecting performance. This approach has as its goal the investigation of cognitive processes through psychological experimentation and manipulation of tasks, the assumption being that task attributes affect the nature of cognitive processes displayed by the subject.

Within this approach one can identify three subapproaches; the first, based upon measuring task performance to reflect process aspects of a general theory of cognition; the second, investigating information processing parameters from experimental tasks to test hypotheses about individual differences; and finally the third is similar to the second but provides a physiological context from which cognitive processes are considered.

The first, which will be labelled the general experimental approach, assumes that certain cognitive processes exist in all individuals and delineation of such will generate hypotheses which can be integrated into general models of cognition. These models, however, do not emphasize or explore the notion of individual differences. Representative of this approach are such investigators as Broadbent (1958),

Norman (1969), and Miller (1962). They have postulated general theories of cognition from experimental situations, specifying such information parameters as: attention, coding, memory, processing time, and errors in processing.

The second and third approaches have attempted to integrate the differential and information processing approaches by investigating individual and task differences to account for cognitive processes. The recognition of the need for a differential-experimental approach was identified by Cronbach (1957) and Carroll(1976) among others. Among those pursuing this approach are: Sternberg (1979), Hunt, Lunneberg and Lewis (1975), Flavell (1977), Brown (1978) and Carroll (1976). The common theme of their investigations is the utilization of cognitive constructs from experimental psychology, and the recognition of the significance of individual differences in describing cognitive performance.

The third approach differs from the second in its addition of utilizing clinical neuropsychology, as a source of information for examining individual differences in cognition. Das and his colleagues (1979) have recognized the need for utilizing such a source.

> "This field (clinical neuropsychology) which studies the various areas of the brain, is obviously relevant because it is describing the nature of the organism which is producing the intelligent actions. Those studies which concentrate on the molar/brain-behavior

relations as opposed to those dealing with molecular or neuronal analyses, are particularly useful" (Das, 1979, p. 30)

Although the investigations by Das et. al are based on clinical neuropsychology they are not directly related to this area. The researchers operate within an information processing approach but utilize neuropsychology as a source for generating hypotheses about underlying cognitive processes.

Although a great deal of research has been generated in exploring such information processing parameters as coding, memory, retrieval and storage, it is only recently that attention has focused on how these processes are deployed, that is how coding processes are controlled, organized, integrated, sequenced and directed towards goal attainment. This area of research would focus on how processing is planned, and what strategies are used to orchestrate component processes such as coding, rehearsal and storage. The present investigation will attempt to explore this higher-level of cognition.

Recently a number of researchers have recognized the necessity for including a planning or executive dimension in information processing. The terms used to describe this higher-level processing have varied, but are consistent in their conceptual focus. Sternberg (1979) has used the word metacomponents to describe a higher-level cognitive processing which involves specific realizations of control over component processes. Brown and DeLoache (1978) and Flavell (1976) have referred to this level

of processing as metacognition, also attributing to it the idea of control over one's own processing. Snow (1978) and Reitman (1965) refer to this process of being directed by an executive mechanism which also controls processing. Both Snow (1978) and Simon (1976) suggest that besides control processes, assembly processes may in fact also reflect the executive function.

The notion of an executive function adopted herein is provided by Das et. al (1979). It is similar in that it is assumed to control processing and involves strategies or plans of action.

> "Thus processes are components of strategies (plans): the strategy involves a decision about which form of processing to apply at a certain point in time in the problem solution." (p. 100)

It is assumed that this higher-level cognitive function is based in the frontal lobes of the brain (primarily the prefrontal division) and involves the synthesis of information from other parts of the brain.

The research reported herein involves three studies of exploring and planning dimension of information processing. Ashman (1978) has established the existence of this third dimension of the Das et. al (1975) model by using a normal adolescent sample. The first study will examine the relationship between cognitive style and coding. The second study will attempt to reestablish the planning dimension on a normal adult population, and demonstrate the effect of training planning strategies on individual performance. The third study will attempt to validate and explore the planning dimension on a complex problem solving task using a normal adult sample.

CHAPTER II

THEORETICAL AND RESEARCH FRAMEWORK

INTRODUCTION

This research investigation is primarily concerned with the executive or planning process of human cognitive functioning. The purpose of this chapter is: 1. to describe the nature of planning in the context of other cognitive functions; and, 2. to provide the theoretical structure upon which this research is based.

Two sources of information providing a conceptual focus for planning can be utilized, namely neurology (and more recently neuropsychology) and differential processing psychology. The former deals with the functional organization of the brain, and the latter deals with what Das et. al (1979) have described as cognitive learning theory.

Both of these scientific endeavours have functioned relatively independently. Lezak (1976) noted that traditionally differences between neurology and psychology have appeared in focus and method.

> "For neurology the study of behavior is a means to an end: the understanding of the nervous system and the treatment of neurological disease. In psychology the study of behavior is either an end to itself or a means of enhancing the prediction or control of behavior. (p. 10)."

Uttal (1978) has speculated that both of these scientific traditions (neurology and neuropsychology) may have developed their theories in response to a set of problems that have concerned humans for thousands of years. That is the set of problems concerned with the relationship between physical structures and cognitive functioning. It has universally been defined throughout the ages as the Mind-Body problem.

Psychology has traditionally treated the problem by posing the mind as either an immutable entity (differential psychology) or as a functioning information processor (information-processing psychology). Neurology on the other hand treated the mind-body problem by analyzing minute behaviors of the central nervous system, reflexes, and motor outputs underlying behavioral acts in invertebrates, and from these inferring a neuropsychological bases (Gazzaniga and Blakemore, 1975).

BRIEF HISTORICAL REVIEW

Attempts at uniting mind and body (brain) have been formulated since antiquity. Heilman and Valenstein (1979) in a historical review note the earliest attempts by Hippocrates in the 5th century B.C. and Herophilius in the 3rd century. Both recognized the brain as the site of intellect and cognition. The authors also point out that attempts at localizing cognitive processes were continued by Vesaliew (16th century). Gall (18th) Broca, Wernicke, Broadman (19th) and finally Lashley and Hend (20th century) among others.

These attempts have stimulated the emergence of a new interdisciplinary science, which has come to be known as neuropsychology. Utilizing cognitive constructs from experimental psychology, and the physiological constructs from neurology, has enabled the evolution of this hybrid science. Within it's boundaries one can distinguish two separate branches-the experimental and the clinical. Although differing in purpose and methodology, they both assume that behavior is mediated by cerebral mechanisms.

The experimental approach (Sperry, 1969; Gazzaniga, 1979; Uttall, 1976) has studied cognition by utilizing such methods as electrical brain stimulation, neurochemical manipulations, and finally electrophysiological studies. Heilman and Valenstein (1979) note that these methods have been used for different purposes. Brain stimulation has been utilized, "to map connections in the brain and to elicit changes in behavior"; neurochemical studies on the other hand, "have correlated the behavioral effects of pharmacological agents with dysfunction in anatomical areas", and finally electrophysiological methods have "demonstrated the connection between EEG activity and behavior". (p. 13-14).

The clinical approach on the other hand has investigated the relationship between dysfunction in certain brain areas and their resultant behavior changes. Ashman (1978) has pointed out that the approach "evolved in response to practical problems and rehabilitation of patients with cortical brain dysfunction and reflects to root of clinical psychology (p. 6)." For the most part this approach has led to a plethora of formal assessment techniques of cortical functioning in brain dysfunctioned individuals. These assessment techniques have a recent history dating back only about fifty years, and involve for the most part, the utilization of clinical or experimental psychological instruments (i.e. Halsted, 1947; Hunt, 1943; Shopley, 1940; Reitan and Davidson, 1974; Lezak, 1976; and Piotrowski, 1937).

The application of these instruments has been somewhat less than promising in conceptually inferring cortical functioning. Many of the instruments used were not able to detect the cortical impairments displayed. Although the diagnoses of individuals may have indicated brain dysfunction, the testing instruments were not able to demonstrate these deficits and limitations. For example many studies have consistently demonstrated that individuals with cerebral lesions continue to perform in the average range of ability. Zangwill (1966) has criticized the use of standardized intelligence tests in defining the nature of cognitive dysfunction, pointing out that these instruments do not measure cortical abnormalities. Dimassio (1979) goes even further by stating that most neuropsychological assessment instruments "do not disclose any abnormality unless patients have associated confusion or non-focal damage".

This problem may in part be dealt with by abandoning the assumption that ability differences reflect performance differences on psychometric tasks (as reflected by differential psychologists).

Das (1973), using the clinical neuropsychological research of Luria (1966) as a basis, has postulated understanding performance requires tasks which reflect component or process differences utilized by the individual.

In our investigation of planning four sources of information will be considered: First, Luria's clinical neuropsychology theory and research; Second, the information-integration theory and research of Das et. al (1975); Third, modern cognitive-learning theory and

research; and finally research on frontal-lobe damage as it relates to planning. Each of these sources will be discussed in this review.

LURIA'S CLINICAL NEUROPSYCHOLOGY

One of the prominent themes in research investigations on the nature of brain-cognition correlates has been the concern with discovering the location of cognitive processes within specific regions of the brain, through lesions.

Over the past two hundred years researchers have attempted to delineate the psychological deficits associated with specific brain lesions. The studies reveal basic differences in attempts of discovering the location of psychological functions. Uttall (1978) in summarizing the research distinguishes two schools of thought on the issue of localization of cognitive functions:

> "the first-radical localization theory asserted that specific mental processes were sharply localized in specific neural centers in the brain. The other radical homogeneity theory asserted that the brain acted en masse as a unified and equipotential organ to mediate mental processes". (p. 352).

Both theoretical positions have been repeatedly challenged by neuropsychologists (Luria, 1966; Valenstein, 1973; Uttall, 1978). This has led to an intermediary position which is based on the idea that the brain is a system which has functions in each psychological process.

One of the strongest and well recognized proponents of this intermediary approach is the Soviet psychologist Luria (1973).

> "mental functions as complex functional systems, cannot be localized in narrow zones of the cortex or in isolated cell groups, but must be organized in systems of concertedly working zones, each of which may be located in completely different and often distant areas of the brain". (p. 31).

Each of these functional systems has a corresponding block or unit within the brain which "introduces it's own particular factor which is essential for normal correct performance" Ashman (1978, p. 8). To observe the location of the blocks one must therefore study the interactions among the different cortical zones. Das et. al (1979) have proposed that although the task may be difficult it remains important for the neuropsychologist to identify the processes within the zones and determine their interactions.

On the basis of his earlier neuropsychological observations of patients displaying cerebral dysfunctions as a result of brain lesions (1966) and later theorizing (1973), Luria described three functional systems or units of the brain. Cognitive functioning is controlled by these three units which Luria (1973) describes as:
Unit (1) - regulating tone or waking; Unit (2) - obtaining, processing, and storing information, and finally Unit (3) - controlling, planning, programming, regulating and verifying the cognitive functioning of the brain.

Each of these units or systems are arranged hierarchically in three zones and are assumed to control the functions of the unit. The three zones are: the primary or projection zone which receives and transmits impulses; the secondary or projection-association zones in which information input is processed; and the tertiary or as Luria describes them - over lapping zones, which are responsible for the most complex forms of mental activity. Each unit or system will be described below.

THE FIRST FUNCTIONAL UNIT (BLOCK 1)

This unit regulates the tone and wakefulness of the numan cortex, a function described as necessary to maintain optimal cortical activity. Included in this unit are the hippocampus, the brain stem, and the reticular formation. Lesions of these brain structures have been reported by Luria (1966) as producing disturbances in arousal and alertness. Luria has suggested that the optimal level of tone and wakefulness is mediated by the reticular formation. Das et. al (1979), in reviewing the work of Luria describe the reticular formation as being concerned with activating the cortex and subordinating the lower structures in the brain to the control of the program arising in the cortex. (p. 38).

The reticular formation therefore assists the optimal level of tone and wakefulness, through three sources of activation; the metabolic process, stimulus arrival, and the individual's intent or planning. The functions of activation and arousal are important in that they direct and in turn are affected by such cognitively complex activities as programming

and planning. Specifically the efferent or descending fibres of the reticular formation enable higher cortical levels to engage lower levels, and therefore it works in close cooperation with the higher levels of the cortex. This notion will be elaborated in our discussion in unit 3.

THE SECOND FUNCTIONAL UNIT (BLOCK 2)

This unit as mentioned previously is involved in obtaining, processing and storing information. It is located in the posterior regions of the cortex, and thereby includes the occipital, temporal, and parietal lobes. This unit (as are the others) is arranged hierarchically into three zones: the primary projection zone; the secondary or projection-association zones; and the tertiary overlapping zones. Each of these zones will be described.

The primary projection zones are conceived by Luria to be the most highly modal specific, while the tertiary zones are almost devoid of modal specificity.

The primary zone responds if the information it receives is identified clearly in terms of modality. Its function is one of receiving and analyzing information into its component elements. The secondary zones contain neurons which are not as specifically modal, thereby enabling stimuli to be organized and coded into patterns. Finally the cells of the tertiary zones are amodal and overlapping. Their function is one of integrating sensory information already coded. These zones lie on the boundaries between the occipital, temporal and post central cortex. Most of them are located in the inferior parietal region. Within the occipital-parietal areas stimuli that arrive success-

are grouped simultaneously into symbolic units, thereby enabling the transformation of information into: holistic abstract thinking, grammatical and logical sentence structure development, and the formation of mathematical relationships.

To summarize, the second unit differs from the others in modal specificity. It enables information to be integrated into successive series or simultaneous groups. It contains three zones that are arranged hierarchically with neuronal impulses travelling afferently from zone 1 to zone 3. Luria (1973) has furthermore postulated that as one progresses from the primary to the tertiary zones an increasing lateralization of functions occurs. Whereas lesions in the primary zones do not produce lateralization differences in function, this is not the case in higher-order lesions in the secondary or tertiary zones.

THE THIRD FUNCTIONAL UNIT (BLOCK 3)

This unit is responsible for planning and programming. According to Luria, Block 3 functions include: the creation of intention; the formation of plans; the regulation of behavior according to these plans; the checking or verification of a plan in achieving the derived results; and finally integration of information from all other areas of the brain. The third unit is located in the frontal lobes of the human cortex, and like the other two units is divided into three zones.

The primary zones (motor) transmits motor impulses to the efferent system, and allows behavior to be carried out. The secondary zones (premotor) organizes body movements. The tertiary zone which is located in the prefrontal division of the cortex was singled out by Luria as

serving the highest functions of man. It is capable of forming intentions, plans, programs and regulating and verifying complex behavior (Luria, 1973). The prefrontal division connects to all other areas of the cortex, and is therefore capable of receiving input from all other areas of the brain, and to stimulate movement through premotor and motor zone areas. As mentioned earlier the third unit is connected to the reticular formation in unit one, enabling it to regulate tone, alertness, and wakefullness.

Damage to this unit (frontal lobe) as reported by Luria (1972), Pribram and Luria (1973), Luria and Homskaya (1964) has resulted in several key cognitive dysfunctions. Among them are: the inability of an individual to detect his own errors; difficulty in carrying out complex verbal instructions; difficulty in planning and starting problems; impoverished information gathering strategies for the solution of problems; and finally the inability to evaluate and verify whether behavior meets original objectives or intentions.

In summary, the third unit located in the frontal lobes plays a very important function of the brain. It regulates, controls and integrates all conscious activity, and is involved in such complex behaviors as problem solving, and involves strategies that are verbally mediated.

LURIA'S METHOD OF TESTING

Before concluding this section it may be useful to discuss Luria's method of testing and contrast it with others. As mentioned in the introduction, the differential approach in psychology has sought to

identify abilities by selecting tests upon which performance differences were demonstrated. Frequently the next step involved identifying high and low performers and attributing levels of ability accordingly. However, this approach does not explore the process underlying abilities.

Luria on the other hand, selected tests to get at systems of functions or processes. In the case of planning for example, Luria would view it as a process and therefore tests of planning would not reflect amounts of planning, but would measure how strategies are used in planning.

CONCLUSION AND SUMMARY

On the basis of his earlier clinical observations (Luria, 1966) and later theorizing (Luria, 1973), Luria described the functional organization of the brain. He described three functional units which are concerned with: Block 1 - (hippocampus, reticular formation and brain stem), tone maintenance and arousal level; Block 2 - (occipital, temporal, and parietal lobes) obtaining, processing, and storing information; and finally, Block 3 - (frontal lobes) programming, planning behavior. Our investigation is concerned with the prefrontal region of Block 3 which "plays a decisive role in the formation of intentions and programs and in the regulation and verification of the most complex forms of human behavior (Luria, 1973 d, p. 84).

Das (1972) has proposed a model of information integration based on Luria's conceptual framework, which was delineated comprehensively by Das, Kirby, Jarman, in 1975. Utilizing factor analytic methods, Das and his colleagues have identified two cognitive processes common to a set

of tests with a non-clinical population. These are simultaneous processing and successive processing. Recently, Ashman (1978) was able to identify a planning dimension common to another set of tests. These cognitive processes are assumed to originate in units 2 and 3.

The Information-Integration Model of Das, Kirby, and Jarman (1975) will be discussed in this review since it provides the methodology and research orientation for the studies carried out in this document. However, before doing so, the research on frontal lobe functioning will be reviewed as it pertains to planning and the executive function.

FRONTAL LOBE FUNCTIONING

Introduction

The frontal lobes which are included in Luria's third unit of the brain are associated with planning behavior. The Soviet neuropsychologist discovered that the frontal lobe seems to be involved in complex behaviors (problem solving) that have to do with organizing responses. Luria thereby attributed to the frontal lobes the highest function of the brain (in Das et. al 1979, p. 41).

In the course of man's evolution it is known that the frontal lobes were the last to develop, and occupy almost half of the cerebral cortex of man. It has repeatedly been associated with higher level cognitive functioning by various researchers.

Anatonomy

To gain an understanding of the frontal lobe it may be useful to delineate it's anatomical structure. Traditionally the frontal cortex has been divided into four regions: the precentral, the premotor, the prefrontal and the limbic. The prefrontal area makes up most of the frontal cortex. To understand frontal lobe functioning requires knowledge of its afferrent and efferent connections.

Dimazio (1979), in reviewing the anatomical structures of the frontal lobe came to the conclusion that it serves a diversity of functions which are reflected in its connections.

First it is cortically linked with the limbic and reticular activating systems; second it is linked to the posterior sensory areas of the brain; and finally it is linked with the motor system of the the brain. Luria (1968) also reported the existence of Block 3 functions

and their linkage to other areas. He noted that the frontal lobes are connected to the reticular formation, the motor cortex and the structures of Block 2 - the occipital, temporal, and parietal lobes (posterior areas).

Various studies will be discussed which indicate that frontal lobes perform functions involving higher-level cognitive processes and regulatory activity. Furthermore the frontal lobes act interdependently with the posterior areas of the brain. This in fact suggests that those cognitive functions that are impaired following frontal lobe damage are concerned with planning, a role incidentally reflected in the Das et. al model.

In the following pages some evidence from frontal lobe damage research will be discussed to demonstrate planning dysfunctions and to guide the measurement of planning. We will discuss evidence from case studies, neuropsychological studies, and clinical assessment.

Case Studies

Dimazio (1979) discusses several case studies provided by Hebb and Penfield (1940), Brickner (1936), and Ackerly and Benton (1948). He concluded that although each case differed significantly in the nature and depth of the lesions performed, the resulting dysfunctions were similar. The patients displayed:

> "lack of originality and creativity; the inability to organize future activity; hold gainful employment and be fully independent; inability to focus attention; recent memory vulnerable to inference;

and a tendency to display inappropriate emotional reactions". (Dimazio, p. 377).

The classic case of Phineas Gage often described in neurology textbooks also serves as an illustration of the psychological processes associated with frontal lobe damage. It is reported that Gage after having recovered from having a crowbar thrust through his frontal lobes displayed dysfunctions in ambition, judgement and organizational processes.

Ashman (1978), in summarizing the results of early studies of frontal lobe damage reported the following: "When accounting for the behavioral effects of frontal lobe damage, earlier studies show a loss of initiative and lack of capacity for planned administration; the destruction of the synthesizer of intellectual operation or engrammatic products emanating from the posterior cortex; interference with mechanisms which are concerned with projection of the individual into the future and disintegration of general intelligence, stable personality and affect, initiative, memory, attention and abstract reasoning" (Ashman, p. 28).

Neuropsychological Studies

Experimental studies have made several contributions to clarifying frontal lobe functions and dysfunctions. One of the most significant contributions has come from Luria's (1961, 1963, 1964, 1969) investigations of patients and normal individuals.

Luria and Homskaya (1964) found that the orienting response of frontal-lobed damaged patients could not be mediated by verbal instruc-

tions. Patients were unable to prevent perseveration and habituation to the stimulus presented even when verbal instructions were presented. The findings suggest that in normal subjects verbal instructions may in fact engage the orienting response and prevent habituation to a stimulus. It appears then that one of the specific cognitive defects accompanying frontal lobe lesions involves the inability to connect verbal behavior to ongoing behavior. The patient is therefore "less apt to use verbal cues (i.e. memory) to guide, direct, or organize behavior" (Lezak 1976, p.66).

Luria (1970), has repeatedly made reference of this inability to suppress a response after it has been deemed unnecessary. Perseverations have been reported by patients using written geometric and verbal stimuli. Milner (1971), has noted that perseveration interferes with the ability to learn new associations to stimuli, or with the ability to perform tasks that require a delayed response. Other investigations have similarly discovered the inability of frontal damaged subjects to alter orienting responses (Simernitskaya 1970, Sommerhoff 1974). It is interesting to note that the inability to engage the orienting response has not been noted in posterior sensory area damage. Luria (1966) reported that patients suffering from gunshot wounds, tumors, and strokes in the posterior sensory cortex are unaffected by perseveration as witnessed by their ability to allow the orienting response to be stabilized by verbal instructions.

Milner (1963), used the Wisconsin Card Sorting Test with frontal patients and a control group. This test requires the subject to sort

128 cards according to shifting criterion with the subject not being made aware of the shift. Milner found a significant difference in performance between frontal patients and the control group, with the former receiving lower scores. The frontal patients displayed difficulty in recognizing criterion shifts and generally continued to sort on the basis of one criterion. Milner interpreted the results as follows: frontal lobe damaged patients display difficulty in shifting strategies even when given verbal guiding instructions and are therefore unable to overcome a response set. This would again suggest that these patients do not make use of verbal instructions directing their behavior. Supporting evidence comes from other experimental studies conducted by Luria and Homskaya (1964). The authors attempted to discover whether frontal patients would in fact be able to carry out a number of verbal instructions ranging from simple to complex. The independent variables included conflicting cues provided by the examiner and principle changes induced in the instructions. The authors found that these subjects demonstrated several defects: the inability to correct errors although recognizing their existence and the inability to perform complex instructions. Luria concluded that the source of difficulty was due to an inability to direct complex behavior by verbal means: "The effect of action is not evaluated, no signal of errors is actualized, mistakes are not corrected" (Luria and Homskaya 1964). These findings are consistent with Luria's explanation of Block 3 functions. The frontal lobes are connected with the arousal functions of Block 1 and play an important role in the regulation of conscious activity.

Ashman (1978), summarizes the implications of these findings:

> "his findings of disturbances in the selective, goal-directed actions under a variety of conditions indicated that the disruptions most often result from the patient's inability to initiate and maintain the plan of action (p. 30)."

Up to this point it seems clear that the dysfunctions associated with frontal lobe lesions involve the loss of selectivity. Das (1978) has noted for example, that the individual does not evaluate performance realistically, as evidenced by the inability to estimate how many words he may be able to repeat; or the inability to analyze the context of passage that requires attention and verification of hypothesis.

In connection with this apparent loss of selectivity frontal lobe functions also "involve activities of selective perception such as visual scanning". (Lezak 1976, p. 64). Teuber (1964) supported this notion using a visual search task which required his frontal patients to view a number of patterns and then search for a duplicate match of one of the patterns. Teuber demonstrated that his patients were slow in their response rate and inefficient in their plan of search. This test was first used to measure the planning dimension by Ashman (1978), and will also be included in the battery of our research investigation.

Finally, Tow (1955), demonstrated that frontal lesions affect abstract thinking and the ability to make effective responsive shifts (similar to Milner's findings of shifting criterion). Armitage (1946), although not specifying the effect of frontal lesions specifically noted that brain damaged subjects were unable or had difficulty perceiving a double relationship to plan to shift between rules and prevent perseveration on a Trail-Making Test. This test was also used by Ashman (1978), in identifying, planning, and therefore is included in our battery.

It seems quite apparent from these experimental studies that the frontal lobe is actively involved in a number of perceptual and cognitive functions having to do with planning and decision-making. Wittrock (1978) in discussing the active nature of frontal lobe functioning, has noted that plans and intentions control and direct selective attention and arousal.

Electrophysiological Studies

A number of electrophysiological studies of behavior have also been attempted to clarify brain-behavior relationships. Though relatively few in number, they nevertheless provide a useful source of information regarding planning and decision-making. These studies have usually relied on the use of the electroencephalogram. Measures of EEG frequency and amplitude in different behavioral situations have demonstrated correlations between behavior and EEG activity.

Electrophysiological evidence on frontal cortex damage provided by Pribram (1971), through experimental studies demonstrated the anatomical connections of Block 1 and Block 3 functions and their importance in

behavior. Pribram gave his subjects a number of delayed alternation and delayed reaction tasks in which the shifting response strategies were measured among other variables. In analyzing the results the author concluded that frontal lobe damage impairs the ability to regulate behavior and correct errors. Pribram also suggested that this self-corrective regulation of behavior is evidenced in problem solving tasks (which require planning and decision-making).

> "the organism is not able to regulate his behavior on the basis of perturbing events that signal changes in context, ...the organism has failed to monitor, register, and evaluate perturbations that continuously complicate context and so add to the troubling present". (p. 347-348).

Restak (1979), in reviewing a number of electrophysiological studies indicates that a "decision-making wave" has been measured in alpha rhythms. Ramey (1979), in reviewing a study by Donchin (1979), (who used the P300 wave as a measure of cortical activity) concludes that this cortical process is related to decision making in that it is mediated by task demands rather than specific inputs to the system and as such requires active processing by the brain.

> "the brain then must actively plan and intend to respond and as such is a dynamic system that continuously generates hypotheses

about the environment that are then validated against input information". (Ramey 1979, p. 16).

This would in fact confirm Luria's (1973), suggestion of an executive process or function in Block 3 controlling readiness, arousal, and attention in Block 1.

In summary a number of characteristics behavioral changes resulting from frontal damage have been noted: 1. Changes in arousal and orienting; 2. Changes in the self-corrective regulation of perceptual and cognitive behavior. Tied to these changes Dimazio (1979) noted the most characteristic dysfunctions displayed by frontal patients are in goal-oriented behavior.

> "lack of insight and lack of foresight are usually quite prominent. Even if able to act on their own, few patients will see the significance of their decisions for themselves and those around them. Planning of near and long-term future will not be possible". (p. 403).

Dimazio goes on to suggest that impairment of goal-oriented behavior is a consequence of an executive or planning and decision making functional deficit. The author hypothesized that a planning deficit may be due to the following factors:

> "either a). the "master plan" is not available for adequate assessment, or
> b). the configuration of stimuli producing

action or non action is not fully appreciated; or c). whatever decisions are made are not carried out as planned".

Luria through clinical observation and experimental studies has interpreted the effect of frontal lobe defects and come to the following conclusions: Frontal lobe patients have difficulty in: strategic problem solving behavior (which involves goal-oriented behavior); self-corrective regulatory behavior; and choice behavior.

Dimazio (1979), concludes that even if these defects cannot be consistently demonstrated by experimental tasks, "one can still encounter them at more complex levels of behavior, for instance in goal-oriented decision process". (p. 387).

Up to now traditional intelligence tests have not demonstrated consistent frontal lobe cognitive dysfunctions. Does this mean therefore that frontal lobes do not control the highest-level of human cognition? The answer may lie in the nature of the tasks presented by intelligence tests: it appears that ability tests have traditionally been unable to measure the control, regulatory, and planning functions essential to frontal lobe functioning. Impairment of high-level problem solving, the result of which is the inability to plan and decide, has so far eluded direct measurement.

The notion of an executive mechanism explored in this section which controls, regulates, plans, and decides has also been given special attention by Das and his colleagues in their model of information integration. At this time it may be useful to examine the model since it provides the theoretical and methodological bases for the studies in this recent investigation.

INFORMATION-INTEGRATION MODEL

Introduction

Das (1972) and Das, Kirby, Jarman (1975), have proposed a cognitive model of information integration based on Luria's clinical observations. Specifically the model derives its notion of simultaneous and successive processing from Luria's observations of the disturbances found in occipital-parietal and frontal-temporal lesioned patients. Luria noted that the occipital, parietal, and temporal lobes process information from various sources either simultaneously or successively. The sources tapped for these processes may be visual, tactile or auditory (Das et. al, 1979).

The major focus of the information-integration model has been with the processes of simultaneous and successive synthesis. These two components of the central processing unit are presumed to be facilitated by the posterior cortex of the brain. Das et. al have developed a battery of tests said to require the activation of these two types of processing. It is important to note that these processes are frequently not linked to specific visual, tactile, or auditory modalities. This notion originated with Luria who noted that information processed in the secondary and tertiary zones are amodal, whereas primary zone processing is modal specific.

Recently, Ashman (1978), has demonstrated commonalities between tests requiring the activation of planning functions which are assumed to originate in the frontal lobe (but which also function with other areas of the brain). Planning was described as the third component of the central processing unit.

Our purpose would perhaps be best served by describing the model which was delineated comprehensively by Das, Kirby and Jarman in 1975.

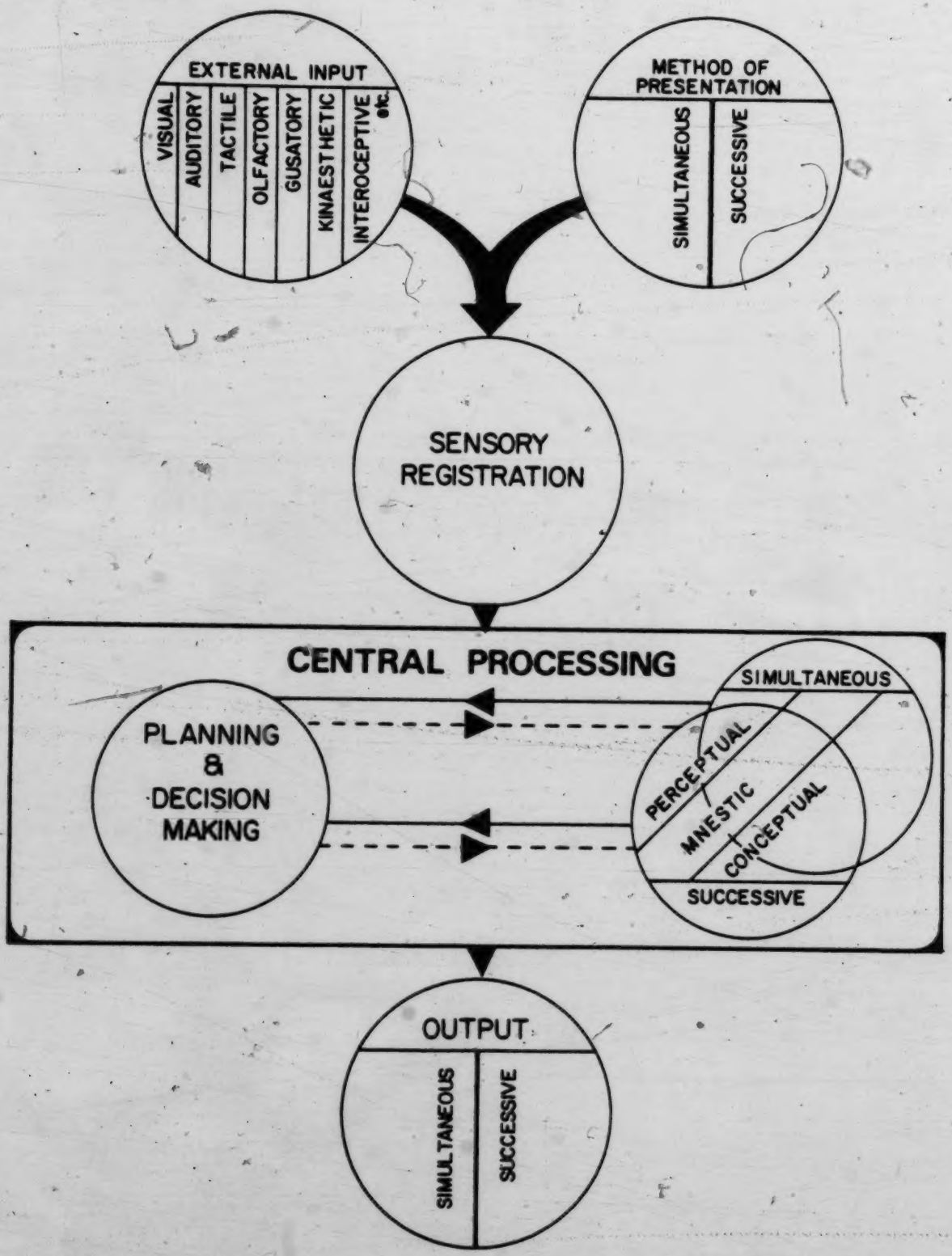
The information integration model hypothesizes four components: input, sensory register, central processor, and an output unit. The stimuli can be accepted through any receptor, and can be presented in either a simultaneous or successive manner.

Stimuli are transmitted to the sensory register, and then passed on to the central processor. The relationship between these two components can be viewed in two ways. The central processor questions or inquires the sensory register to determine if anything is there, and if so, allows a transmission to be made. On the other hand, the sensory register can interupt the processor and compel it to accept information.

The central processor has three components. A unit which processes separate information into simultaneous groups. The essential nature of this processing is that "any part of the result is surveyable without its dependence upon its position in the whole (Das, Kirby and Jarman, 1979, p. 49)". Another unit processes discrete information into successive series or in a serial order. Both modes of processing are assumed to be available to the individual. The selection of either or both modes is determined by the individual's habitual mode of processing information and by the demands of the task. The third unit of the central processor has been described as the planning and decision-making unit. It uses coded information and determined the best possible plan of action.

The output unit of the information integration model determines and systematizes the execution of the response in accordance with task demands.

Figure 1 - Model of Information Integration



VALIDATION OF THE CODING AND PLANNING FACTORS

CODING

Extensive investigations have been carried out to operationalize and measure the two coding processes of simultaneous and successive synthesis (see Das, Kirby and Jarman, 1979). Before continuing it is important to note that these processes were measured using normal rather than brain damaged subjects and therefore reflect individual differences in cognition. Furthermore, the tests used to measure these coding processes do not measure the ability of the subject to orchestrate or deply these processes optimally. As Das et. al (1979) noted, this process skill is "involved in what are referred to as strategies, plans, or programs, and is more accurately a function of the third unit of the brain". (p. 52). Finally, the methods employed to investigate these processes are statistical (specifically factor analytic). The position taken by Das and his colleagues is that factor analytic methods are capable of extracting factors which can be confirmed and explained.

Tests

The tests used to measure successive processing (which requires maintaining a temporal sequence of input stimuli) are Digit Span, Visual Short-Term Memory, and Serial or Free Recall. These tests will be described in detail in the following chapter of this document. Using a wide variety of samples these measures have been found to consistently load on the factor identified as successive processing. It is interesting to note that even though the tests are memory tests, they do not consistently load on a memory factor. Das and his

colleagues have found that other memory tests seem to load more on the simultaneous factor.

Simultaneous processing on the other hand which requires the construction of a spatial pattern scheme or gestalt has been measured by the following tests: Raven's Progressive Matrices, Figure Copying, and Memory for Designs. These measures have been found to load on the simultaneous factor consistently across a wide range of subjects.

In summary, this coding dimension of the Das et. al model has remained stable across widely differing groups including learning-disabled children, high and low achievers, high and low caste children, retarded children, normal adolescents, normal adults, and Canadian Indians (see Das et. al, 1979).

STRATEGIC PLANNING

Ashman (1978) discovered the planning dimension of the central processing unit of the Das et. al integration model. As with coding, this process was measured by using subjects which were not brain-damaged. Planning or the executive function as noted earlier, refers to a process which involves the deployment and orchestration of coding processes, and involves structuring behavior in order to fulfill plans. This function is assumed to originate in Block 3 of Luria's model, and has been termed by Das (1973) as the highest function of man.

Das et. al (1979) have hypothesized that normals and retardates employ different strategies or plans in solving tasks. Strategies were defined as "involving a decision about which form of processing

(simultaneous or successive) to employ" (p. 100). The inference being that a higher level cognitive process (planning and strategic behavior) mediates, controls, directs, and regulates lower level coding processing. It is postulated that the strategy or plan of action chosen by an individual is a function of four factors:

> "the coded information available to the individual (eg. his past experiences), his habitual way of responding in certain situations (perhaps culturally determined), the processes he is able to use, and the outcome demands of the task. (Das, Kirby and Jarman, 1979, p. 100)".

In discussing the relationship between planning or strategic behavior and coding, Das (1980) has concluded that in Ashman's (1978) study,

> "the emergence of a planning factor is possible because of the presence of additional variance over and above that which can be explained by coding tasks. In other words, over and above a minimum amount of planful behavior which might be involved in coding tasks, the planning tasks in our studies had some additional variance to explain". (p. 14).

Therefore, the assumption is that coding "provides content for planning to act on". The independence of these two processes also comes from Luria's clinical observations of brain lesions in which frontal damaged patients demonstrated deficiencies in planning,

while occipital, parietal, and temporal lesioned patients demonstrated severe coding dysfunctions. Finally, supporting evidence of the independence of these processes comes from a number of research investigations of cognitive learning research (Sternberg, 1979; Brown, 1974; Scandura, 1974; among others) which will be discussed in the next section.

Tests

The construct of planning has up to this point been defined in a general and vague fashion. It has included the notions of strategies, plans, and programs which enable the individual to control, regulate, monitor, organize and sequence a number of coding processes in the pursuit of a goal. There are very few tasks either experimental or real-life which do not involve planning to some degree.

In order to choose tasks measuring planning, Das (1980), has suggested that one might select tests used to measure frontal lobe functions, thereby providing potential indices of planning. The tasks used in detecting deficits such as planning, simultaneous and successive processing, have correlated highly in normal populations, and are therefore useful in attempting to measure individual differences.

Ashman (1978), in reviewing the literature, found the following tests to have been used to measure frontal lobe functions: 1. the visual search test (Teuber, 1964); 2. the trail-making test (Armitage, 1946); 3. the verbal fluency test (Thurstone, 1941); and 4. the planned composition test (as in Ashman, 1980). Dimasio (in Heilman and Valenstein, 1979) further noted that other tasks used to

measure frontal lobe functioning included: 1. The Wisconsin Card Sorting Test (Berg, 1948); 2. Body Orientation Task (Teuber, 1964); 3. Visuopostural Orientation Task (Teuber, 1964); and 4. Reversal-of-Perspective Task (Teuber, 1964).

The tests used in this study among others included those used by Ashman (1978) in identifying a planning dimension: 1. the visual search task, 2. the Trail-making Test, and 3. planned composition.

Ashman (1978) conducted three studies using both planning and coding tasks. In the first study a normal sample of grade 8 children were tested on the simultaneous-successive battery, and the four planning tasks mentioned previously. The first factor identified by a principal component factor analysis emerged and was labelled as planning. It contained high loadings from the Visual Search, Trail-Making, Verbal Fluency and Planned Compositions tasks. The second factor emerged from the Matching Familiar Figures test, and thereby did not appear to load on the planning factor. The third and fourth factors emerged from the simultaneous and successive marker tests, and confirmed results from many earlier studies. The fifth factor emerged from the visual short-term memory and Porteus-maze tests.

In the second study, Ashman tested a sample of 46 educable mentally retarded adults, using the Visual Search, Trail-Making, Planned Composition and Verbal Fluency Tasks, and the same simultaneous-successive battery used in the first study. The results of the factor analysis

(see Table 2) again demonstrated the emergence of the planning factor, the successive factor and the simultaneous factor.

Finally, in the third study, 40 educable mentally retarded subjects ranging from 12 to 22 years of age, were administered two tests from each of the simultaneous, successive and planning tasks. The results (see Table 3) also yielded the three factors characteristic of simultaneous, successive, and planning tasks, thereby confirming previous results.

In summary, Das (1980) has pointed out that the results of Ashman's studies make it clear that planning emerges as an orthosonal factor. This view is consistent with that of other cognitive learning theorists and researchers, who have postulated an executive or planning function. (These will be discussed in the next section).

COGNITIVE LEARNING RESEARCH AND THE PLANNING FUNCTION

Although using differing descriptors, a number of investigators in information-processing research have sought to explore the planning and decision-making component of higher level cognition by using problem-solving tasks.

Implicit in this research and theorizing is the notion that understanding ability is best facilitated by examining underlying cognitive processes in problem-solving tasks. Furthermore, these processes are not immutably fixed but are trainable, and finally, processing occurs at a higher (i.e. planning) and a lower level (i.e. coding).

Sternberg (1979) has used the term meta-components to denote "higher-order control processes used for planning how a problem should be solved, for making decisions regarding alternative courses of action during problem-solving, and for monitoring solution processes." (p. 1). The author distinguishes between components and meta-components by stating that the former denote the processes one utilizes when one actually solves a problem, while the latter refer to the processes one uses in deciding how to solve a problem. Sternberg (1979) has identified six metacomponents believed to be present in cognitive behavior: "1. selection of lower order components (i.e. performance, acquisition, retention or transfer) to be used in the solution of a task; 2. selection of one or more representations or organizations for information; 3. selection for strategy for combining lower order components; 4. decision as to the consistency with which a strategy should be executed;

5. decision regarding speed-accuracy trade off; 6. solution monitoring." (pp. 8-11).

In sum, Sternberg suggests that meta-component processes regulate and control both what and how components, representations, and strategies are used in solving problems. Of all the research and consequent theorizing of this executive process, Sternberg's work is certainly the most exhaustive within cognitive learning research.

Scandura (1977) uses the term control mechanisms to denote the higher level process of planning, involved in problem-solving behavior: control mechanisms enable the individual to decide which rules to use and when to use them. Gagné (1977) used the term "cognitive strategies" to explain the higher level process involved in approaching and solving problems. These strategies direct the goal-orientation of problem-solving and control such "...processes as 1. attending and selective perceiving; 2. coding for long term storage; and 3. retrieval..." (p. 167). Again it appears that cognitive strategies control, regulate, and mediate various cognitive and perceptual processes. They enable the problem solver to search for relevant aspects, store strategies previously used and evaluate outcome probabilities.

Miller, Galanter and Pribram (1960) also recognize the significance of the planning function. They describe a unit of cognition which acts out a complete problem-solving sequence, "a plan is any hierarchical process in the organism that can control the order in

which a sequence of operations is to be performed" (p. 16). A plan involves strategies, programs, and procedures and is therefore also a higher level or executive process. The mechanism which mediates the execution of a plan is the TOTE (test-operate-test-exit) system. It involves specifying the necessary knowledge (test phase), and acting on it, either covertly or overtly (operate phase).

Flavell (1977) notes that humans often fail to solve problems for which they already have the necessary solution procedures. One is reminded of Luria's studies which indicated that frontal lobe subjects were able to recognize their errors and verbalize the correct procedure for solution, but were unable to correct these errors. Both researchers recognized that this deficit may originate in defective executive planning strategies. Flavell used the term metacognition to refer "to the active monitoring and consequent cognitive objects or data on which they bear, usually in the service of some concrete goal or objective" (p. 232).

Reitman (1965) discussed the General Problem Solver (GPS) which is a computer-based problem-solving system developed by Newell and Simon (1960). This hierarchically arranged system has an executive and set of methods which allow the executive to set up, evaluate, and attempt goals. The methods of this system are in fact, general strategies or plans which are mediated by the executive. Reitman also discusses the Argus computer program which is modelled after the GPS and includes an executive mechanism so simulate human problem-

solving. The assumption made by Argus is that centralized control in thinking operates to a high degree in goal-directed problem-solving behavior.

Snow (1978) also makes reference to an executive function in information processing, but allows that most research has been directed towards viewing the executive function as a control process. Snow suggests that the primary function of the executive may in fact be assembly rather than control, that is, the efficiency of the individual to organize processing strategies. Simon (1976) suggests that although the same basic processes (i.e. lower level) may be engaged in different tasks, how they are organized in performing a task may differ:

> "proficiency in a task may depend on how the basic processes and relevant knowledge have been organized into the program for task performance" (p. 96).

Posner (1973) also recognizes the need for an executive function in information processing. The basic unit of this function is described as a plan or search strategy which directs the individual towards the goal. It is similar to the TOTE mechanism described by Miller, Gallanter and Pribram (1960), in that the plan involves a sequencing of mental operations directed towards a final goal. In order to assemble a plan, Posner (1973) points out that the individual:

> "must take account of the initial representation, the likely organizing principles of

his own long-term memory, and the

mental operations he can perform" (p. 162).

In reviewing the cognitive learning theories and investigations, it has become apparent that a planning or executive function does exist in information processing, and that it involves a strategy component in relation to coding or lower level processes. Furthermore, its functions include regulating, monitoring, controlling, assembling, organizing, and goal-orienting behaviors, which are not fully understood at the present time.

In terms of measuring the planning function our review also demonstrates that the analysis of problem-solving behavior is a suitable means of specifying the psychological process of planning. In fact, it seems clear that problem-solving tasks are able to demonstrate the role of planning in higher order thought processes.

Finally, in relation to learning, it appears that the planning function as manifested by the utilization of efficient and inefficient strategies may be susceptible to training effects. This was demonstrated in a recent experimental study by Atkin (1979).

Atkin demonstrated the effect of training the planning or control function, in supporting a model of learning and problem-solving based on Ausubel (1968) and Newell and Simon (1972). In her model, Atkin attempted to specify the higher level cognitive processes involved in the capacity to integrate new knowledge with existing relevant knowledge in cognitive structure (this was seen as a necessary condition for learning). Atkin (1979) postulated that the failure of the control processes in problem-solving may be due to:

the selection of an inappropriate problem space; an inadequate monitoring of errors; the incorrect application of heuristic methods; or finally, an inappropriate selection of coding operations.

In her study students were rated on their problem-solving ability and prior knowledge of certain concepts and then given instructional treatments. Atkin's hypothesis stated than an interaction between problem-solving ability and instructional treatment existed "when the treatments bein compared differ in the degree to which they guide the control processes necessary for learning (p. 16)". Her results confirmed the hypothesis in that subjects scoring as lower problem solvers were generally unsuccessful in utilizing new information (ie. treatment #1) to solve a complex problem. Atkin interpreted her results as supporting the model hypothesized initially.

> "...the use of this knowledge in learning and complex problem solving will not occur unless the cognitive control processes are efficiently executed (p. 16)".

In summary, the information processing models and research discussed herein, view the human as an active processor that is capable of using higher level (ie. planning) and lower level (ie. coding) processes. Furthermore, although the descriptors used to identify the planning or higher level cognitive processes differ (ie. rules, totes, plans, strategies), the models recognize the importance of including an executive function in their theories of cognition. Finally, the researchers implicitly recognize that individual differences in performance on problem-solving tasks may be attributable to differences in the utilization of effective or ineffective strategies, which are, in fact, manifestations of executive functions in cognition, and are susceptible to training effects.

CHAPTER III

Study I: Field Independence-Dependence and Simultaneous-Successive Processing

In this study, an attempt was made to explore the relationship between coding and cognitive style. Recently, a new cadre of psychologists and educators have proposed a construct dealing with individual differences in the Das et. al model. The label for this relatively new construct has come to be known as cognitive style - a habitual mode of processing information that an individual adopts in attempting to deal with the environment.

The information processing habits "represent the learner's typical modes of perceiving, thinking and remembering, and problem-solving. They are stable, relatively enduring consistencies in the manner and form of cognition. (Messick, 1970).

This formulation of processing has led to the development of certain tests to measure these habitual differences. In the research on cognitive styles, Gander (1973) defined two main branches--general theories on cognitive styles, and information processing theories of cognitive structures. The theories of cognitive style focus on general characteristic modes of gathering and organizing information without specifying how they relate to the existing cognitive structures necessary for such habitual modes. On the other hand, the information processing theories tie processing modes to structures.

The work of Das et. al can be seen to fit this latter branch, while the constructs of Witkin and other cognitive researchers appears to be more descriptive of the general cognitive style theories.

Nevertheless, the notion of cognitive styles expressing individual differences in habitual ways of processing information appears to be

closely related to the coding and planning dimensions of the Das et al. model. Das, Kirby, and Jarman (1979) postulate that cognitive styles:

> "will be intimately related to what we have termed Block 3 functions, the control and sequencing of cognitive operations in the solution of a task. We have seen...how subgroups can differ in their approaches to cognitive tasks with regard to the use of simultaneous and successive processing. From this perspective, simultaneous and successive processing can be seen as cognitive styles, or as ways of processing information. At the most general level then, cognitive styles can be related to the planning function, or the sequence of cognitive operations that is selected by the individual in response to a problem situation." (p. 140).

Field Independence-Dependence

The most extensively researched and theorized cognitive style is field independence which was formulated by Witkin and his associates (Witkin, Dyk, and Faterson, 1962). Before postulating a relationship between Witkin's field-dependence-independence dimension and the coding

and planning dimensions of Das et al., we will first describe the theory of Witkin.

The field independence-dependence theory is arranged hierarchically in pyramid form, such that differentiation is at the apex, followed by field independence-dependence; restructuring and interpersonal competencies; and finally, disembedding, spatial visualization (Witkin, 1977). Witkin reports that factor analytic research has partially supported each of the various parts.

Witkin et al. (1962) pictured field independence as the perceptual component of a broader-based aspect of intellectual functioning which is referred to as analytical-global. The analytical individual has a highly developed ability to overcome embedding contexts and to experience items separately from the field in which they are contained. On the other hand, the global individual exhibits a style of functioning which submits to the overall organization of the field and which experiences it as part of the background (Witkin et al., 1962). Witkin suggests that performance on tasks developed to measure field independence is strongly affected by the degree to which an individual experiences the world in a differentiated or separated fashion. Therefore, Witkin in extending the perceptual phenomenon to internal modes of processing and experiencing, assumes that differentiating on perceptual tasks is a relevant aspect of cognitive processing as well.

Coop (1977) in examining the research to support the linking of perception and cognition reports two studies by Hochman (1971) and Eisner (1972). In each of these studies the Stroop Test was used.

This test involves a series of tasks involving colors of ink on a card. The inks are used to print color names but do not correspond to the color of ink. Both researchers demonstrated a significant relationship between Stroop Scores and field independent scores (high field independents also scored high on the Stroop test). Coop argues that the Stroop Test, although involving perception, also calls on cognitive process more specifically than Witkin's measures. More research is needed to establish this link hypothesized by Witkin.

One of the methods used to assess an individual's degree of field dependence-independence has been the Group Embedded Figures Test (GEFT). In the GEFT, the subject is required to identify a simple geometric figure which is embedded in a complex design. The subject's score is represented by the number of correctly identified and drawn figures.

Coding and Cognitive Style

As mentioned previously, simultaneous processing involves synthesizing input elements into groups generally having spatial overtones. This type of processing described by the Das et. al model, is required for the formation of a holistic gestalt, and would be present in the coding of figures and the discovery of the relationship between these figures. Characteristically any part of the resulting syntheses can be surveyed irrespective of its order or position within the synthesis. On the other hand, successive processing is involved in the sequential ordering of input. In this type of processing, it is important to maintain a temporal sequence.

One would anticipate that tasks such as the GEFT would logically

link to simultaneous processing and not to successive processing. That field independence-dependence would in fact overlap with quasi-spatial factors such as simultaneous processing is not surprising. McGee (1979) in reviewing factor analytic studies in the area of spatial abilities, concluded that tests measuring field independence and spatial abilities load on a factor he identified as similar to a spatial orientation factor. Similarly, Vernon (1972) in attempting to asses the distinctiveness of field independence, concluded that the group and paper and pencil perceptual tests do not define a factor distinct from general intelligence(s) and spatial ability of visualization. Therefore, it may be suggested that the GEFT task does not measure a unitary factor identified as field independence, but does in fact overlap with other constructs. In order to test the empirical validity of the field independence construct, it would seem appropriate, therefore, to investigate the component processes required in GEFT performance.

What is the nature of the relationship between simultaneous processing and field independence-dependence? Vernon (1972) has speculated that GEFT performance may be closely allied with a spatial factor in that the subject must be able to "hold in mind the structure and properties of a form or figure grasped as a whole." (p. 371). Similarly, Das, Kirby and Jarman (1979) state that in order for a task to measure simultaneous processing its solution will require the construction of a spatial pattern or scheme. It appears then, that successful performance on the GEFT may in fact require that the subject code the stimulus material simultaneously and not successively. This hypothesis will in fact be explored in our first study.

Method

In this first study, an attempt was made to investigate the relationship between simultaneous processing as described by Das et al. (1975) and the cognitive style of field independence-dependence as formulated by Witkin (1954).

Subjects

Fifty first year students enrolled in two programs at a community college acted as volunteer subjects. These programs typically draw students from a cross-section of socio-economic status. The students ranged in age from 18 to 45 years, and had a mean age of 21.74. The sample comprised equal numbers of male and female subjects.

Tests and Procedure

Following the previous research on coding (Das, 1973), two marker tests, Figure Copying and Memory for Designs were selected for simultaneous processing, while Auditory-Serial Recall and Digit Span would be chosen as markers for successive processing. The Group Embedded Figures Test was chosen to measure field-independence/field dependence.

1. The Group Embedded Figures Test (GEFT) can be considered essentially perceptual in nature. Lezak (1976) identified this test as involving tasks with visual interference. "The stimulus material contains the complete percept but extraneous lines or designs encompass or mask it so that the percept is less readily recognizable (p. 290). In the GEFT, there are 18 items that contain several different tasks each one involving one or more simple figures and one or more complex figures. The subject is required to find the "hidden" simple figure by tracing it's outline which is embedded in the complex one. The test

is divided into two sections, each section containing nine problems. Subjects are allowed five minutes for each section. The score is the total number of simple figures identified for each figure. The higher the score, the closer the individual corresponds to Witkin's cognitive style of field independence. The lower scores reflect field dependent strategies. The norms are available in Witkin's GEFT manual.

In addition to the GEFT test of cognitive style, the following four marker tests drawn from the simultaneous-successive battery (Das et. al, 1975) were administered. These are as follows:

2. The Figure-Copying (FC) test, as well as the Memory for Designs test appear to combine perceptual functioning with a motor response, and also contain a spatial component. In this test, 12 figures of increasing difficulty are presented to the subject in a booklet and the subject is then asked to reproduce these geometric figures in the order they are presented. The 12 figures were used by Ashman (1978) and are derived from the Developmental Test of Visual Motor Integration (Beery, 1967), the Developmental Test of Readiness at the Gesell Institute, and from the figures prepared by Ashman (1978). This test has consistently loaded on simultaneous processing.

3. The Memory for Designs (MFD) consists of 15 geometric designs that vary in complexity. They are presented on slides and are projected onto a screen for one second each. Immediately after each exposure, the subject draws what he/she remembers of the design. The reproductions are scored 0,1,2,3, with 3 being poor. The test is derived from Graham and Kendall's original MFD (1960). This test has also previously

loaded on simultaneous processing.

4. The Digit Span (DS) test is similar to the one presented in the WISC-R (1974). The lists of digits of increasing length are presented to the subject verbally. The subject is to recall the digits verbally in the correct order. The total score is the maximum list length that the subject recalls correctly. This test has previously loaded on successive processing. This test also measures verbal memory.

5. The Auditory-Serial Recall (ASR) test contains 16 lists of words (beginning with a four word series and progressing to a seven word series) which were presented to the subjects. This test was prepared by Ashman (1978) and was found to load on successive processing. The score on this test was calculated by summing the number of words recalled in the correct serial order for each trial.

The following tests were administered to groups of students during class time: Memory for Designs, Figure Copying, and the Group Embedded Figures Test. Digit Span and Auditory Serial Recall, were administered individually. A period of approximately twenty minutes was required for the individual battery, and fifty minutes for the group battery. All testing was carried out in a span of two weeks.

Results:

The results in the first study was to determine whether the field independence test would define a factor distinct from the coding marker tests as defined by Das et. al (1975). More specifically, the research question sought to establish the relationship between simultaneous processing and field independence. Correlation and factor analysis were

used to produce a simple factor structure to account for the coding and cognitive style dimensions. In attempting to produce factor solutions a principal component analysis with oblique and orthogonal rotations, was carried out. Kaiser's criterion was used to establish the number of factors to be extracted; therefore only factors having latent roots greater than one were extracted.

The Coding and Cognitive Style Tests

The means and standard deviations of the four coding tests and the cognitive style test can be seen in Table 1 and the correlations between the tests in Table 2. An examination of Table 2 indicates that the Group Embedded Figures Test correlates significantly ($p<.01$) with the Figure Copying and Memory for Designs tests, and does not reach significance with the Digit Span and Auditory Serial Recall tests.

Table 1

Means and Standard Deviations of

Field-independence, Simultaneous and Successive Tests for Total Sample (N=50)

Variable	Mean	Maximum Score	Standard Deviation
Digit Span	6.72	(9)	1.21
Auditory Serial Recall	56.86	(72)	13.06
Figure Copying	14.36	(24)	4.35
Memory for Designs	45.92	(50)	4.10
Group Embedded Figures Test	10.00	(18)	4.10

Table 2

Intercorrelations between the five tests for the Total Sample (N=50)

	DS	ASR	FC	MFD	GEFT
Digit Span (DS)	1.000				
Auditory Serial Recall (ASR)	.433	1.000			
Figure Copying (FC)	-.220	-.048	1.000		
Memory for Design (MFD)	-.217	-.053	.635	1.000	
Group Embedded Figures (GEFT)	.033	.040	.406	.346	1.000

Table 3

Principal Component Analysis with Varimax Rotation of Simultaneous-Successive Marker Tests and the Field-Independence Test (N=50)

Variable	Factor		h^2
	Simultaneous	Successive	
Digit Span	-150	839	726
Auditory Serial Recall	060	830	692
Figure Copying	861	-151	764
Memory for Designs	821	193	530
Group Embedded Figures	702	-174	705
Variance	2.019	1.398	3.417
Percentage of Total Variance	40.40	28.00	68.40

[1]Decimals omitted

The correlation matrix was subsequently submitted to a principal component analysis and two factors with eigen values greater than 1.0 were rotated according to an orthogonal (Varimax) and oblique (Promax) criterion. The factor loadings are reported in Table 3 and Table 4. The Burt-Banks formula was used to establish acceptable values for the loadings to be judged significant (2 factors, $p < .01, = .346$). An examination of Table 3 reveals a commonality between the Figure Copying Test, Memory for Designs, and the Group Embedded Figures and these tests define Factor 1. The Digit Span and Auditory Serial Recall show a commonality and define Factor 2. The factor structure shown in Table 3 conforms to previous findings, (for example, Das et. al, 1975; Ashman, 1978) with Digit Span and Auditory Serial Recall defining Factor 2 (successive processing) and Figure Copying and Memory for Design defining Factor 1 (simultaneous processing). The Group Embedded Figures Test also figures prominently in the first factor loading significantly with the other marker tests of simultaneously processing.

An examination of Table 4 oblique (Promax) solution does not yield more simple, or significantly different factor structures to those found by orthogonal rotation.

Summary:

The results in Study 1 confirmed the theoretical relationship which was hypothesized to exist between the simultaneous and successive tests (Table 3 and 4). The relationship between the simultaneous tests and the field-independence test was also consistent with the theoretical prediction advanced earlier.

Table 4

Principal Components Analysis with Oblique Rotation of Simultaneous-Successive Marker Tests and the Field-Independence Test (N=50)

Variable	Factor		
	Simultaneous	Successive	h^2
Digit Span	-180	843	744
Auditory Serial Recall	030	827	685
Figure Copying	866	-179	782
Memory for Designs	827	170	713
Group Embedded Figures	695	-200	523
Variance	2.034	1.413	3.447
% of Total Variance	40.30	28.00	68.30

CHAPTER IV

Study 2: Simultaneous-Successive Coding and Planning

In this study, an attempt was made to determine the relationship between planning and coding (simultaneous and successive synthesis). Ashman (1978) as was pointed out earlier, did establish a planning dimension orthogonal to coding using and adolescent sample.

The major differences between this study and that carried out by Ashman (1978) are as follows: first, some of the tasks previously included in the test battery were administered to a normal adult population, primarily to capitalize on his findings for interpretation of results. Second, an additional task was added to the planning test battery which differs in nature from other tasks in the level of cognitive complexity, and which is used in problem-solving research. Third, a number of interventions were built into the study to extend the theoretical foundations of the selected tasks, thus allowing for stronger interpretations of the planning functions as described by Das (1978). Fourth, this study in addition, used analysis of variance techniques for the purpose of isolating potential task parameter and individual differences.

Before examining the specific instruments and specifying the statistical techniques to be utilitzed in this study, it may be in order to discuss the general approach used to fulfil the objectives of this study.

First, the literature was reviewed as it pertained to the information processing construct of planning and the tasks which might engage this construct. It was found that the construct of planning had a history of

theoretical and empirical support. Specifically, support came from the following areas: clinical neuropsychology (Luria, 1964, 1966, 1969, 1973): the information-integration model and research of Das et. al (1973, 1975, 1979); cognitive learning research (Sternberg, 1979; Snow, 1978; Flavell, 1977), and frontal lobe clinical and experimental findings. It was also demonstrated that a set of tasks were available to be utilized to examine the planning function.

Secondly, the task properties were examined after they were placed into the test battery. The concerns here were: to replicate previous findings; to determine whether the tasks reflected individual differences; to demonstrate the effect of strategy manipulations; and finally, to investigate the construct validity of the tasks. In regard to the latter: 1. theoretical hypotheses of the underlying construct are formulated, 2. demonstration of the individual task effects are interpreted as supportive of the underlying construct, 3. the measures are then judged as to their relevance of the construct, and finally, 4. a hypothesis is made that the measures (of task performance) sharing the same operation will be statistically related (Rosen, 1978).

Method

Subjects

Sixty first year students enrolled in four programs at a community colleged acted as volunteer subjects. These programs typically draw students from a cross-section of socio-economic status. The students ranged in age from 18 to 40, and had a mean age of 22.6. The sample was comprised of 35 female and 25 male subjects.

Tests and Procedures

The tests used in this study to assess the coding and planning functions were taken from the coding battery developed by Das, Kirby and Jarman (1979), and the planning battery established by Ashman (1978). Included in the coding battery are: two tests measuring simultaneous processing (Figure Copying and Memory for Designs), two tests measuring successive processing (Digit Span and Auditory Serial Recall), and three tests used to measure planning (Trail-Making, Visual Search and Planned Composition). In addition, a syllogistic reasoning test was used to investigate its potential role in planning.

Simultaneous Processing

1. Figure Copying (FC) and 2. Memory for Designs (MFD). Both of these tests are described in Study 1.

Successive Processing

1. Digit Span (DS) and 2. Auditory Serial Recall (ASR). These tests are also described in the first study.

Planning

1. Trail-Making Test (TMT)

This test was originally part of the Army Individual Test of General Ability (1944) and was adopted by Armitage (1946), Reitan (1955) and Spreen and Geddes (1969), to screen for possible neurological deficits. As mentioned previously, Armitage (1946) noted that his subjects were unable or had difficulty perceiving a double relationship and to plan to shift between rules and prevent perseveration. The Trial-Making test has two forms; an Intermediate (ages 5-14) and an Adult

form. Each form is divided into Parts A and B. Part A required the subject to connect in the correct order encircled numbers which are randomly dispersed on the page. In Part B letters and numbers are used and the subject is required to draw lines alternately between letters and numbers in the correct increasing sequence (ie. 1, a, 2, b, 3, c.....). The procedure outlined by Armitage (1946), was followed with the exception that both Intermediate and Adult forms were administered to all subjects. The total elapsed time required for completion was recorded.

After having completed this task, the subject was then required to perform an additional task in which particular strategy manipulations were introduced. The subject was given two parts, A and B. In Part A the task required the subject to connect in the correct order a sequence of numbers from 1 to 14. The numbers were arranged in such a way that the odd numbers were located on the right side of the page beginning with number 1 on the top right and ending with number 13 on bottom right. The even numbers (2, 4, 6, 8, 10, 12, 14) were also distributed from top to bottom. The elapsed time required for connecting numbers 1 through 7, and 8 through 14 were recorded separately. In Part B, the subject was also required to draw connecting lines between numbers. However, the numbers (1-14) are distributed differently than in Part A. In Part B, numbers on the right side of the page were arranged in the following top to bottom order: 1, 4, 5, 8, 9, 12 and 13, while on the left side of the page the numbers were 2, 3, 6, 7, 10, 11, and 14. As was the case in Part A, the elapsed time for connecting numbers 1 - 7, and 8 - 14 were recorded separately.

2. Planned Composition (PC)

This test has been demonstrated to have a high loading on the factor

identified by Ashman (1978) as planning. It would appear that when subjects are required to compose a short essay the capacity to structure material and to plan would be manifested in their performance score. This is supported by the research findings of Christensen (1974). The author found that frontal lobe patients displayed perseverations and an inability to maintain an overall plan in writing.

A procedure for rating high school essays was provided by Diederich (1974). The procedure was based upon a factor analytic study of composition grading conducted at the Educational Testing Service. Five dimensions are identified in the procedure: Ideas, Usage and Structure, Organization and Analysis, Wording and Phrasing, and Individuality. A rating sheet based on a Likert-type scale provided guidelines for high, medium, and low standards in each dimension.

The PC rating used in the study employed a scale similar to Diederich's in which raters were asked to evaluate Expression (thought given to the topic and the capacity to express ideas), Organization (existence of an underlying plan and logical sequence of material), Wording (usage of correct and imaginative words), Mechanics (sentence structure, punctuation, and spelling), and finally Individuality (creative and original composition of ideas).

The second card of the Thematic Apperception Test (Murray, 1943) (country scene mural by Leon Kroll), was projected onto a screen for twenty minutes. The subjects were given a blank sheet of ruled paper and asked to compose and write a one page story about the projected picture. Each composition was transcribed onto a rating form, which was distributed to four community college English instructors for evaluation. The instructors were asked to read each composition; the descriptors for each dimension to be rated; and then to assess the composition by circling the number represented by their evaluation

of the story in each dimension. The total rating for each subject's organization dimension was then computed.

3. Visual Search Task (VS)

This test was originally developed by Poppelreuter in 1917, and was used by Teuber et. al (1949). Teuber in using the visual search task, required his brain lesioned patients to view a number of patterns (on transparencies) and then search for a duplicate match of one of these patterns. As was mentioned previously in the review, Teuber demonstrated that his subjects were slow in their response rate and inefficient in their plan of search. This task was used by Ashman (1978) and was found to receive a high loading (from a principal component factor identified as planning).

The instruments and procedures outlined by Ashman were used with the following exceptions. In addition to presenting the initial set of transparencies, two additional sets were developed, to introduce strategies used in visual search scanning. That is, a set of transparencies which demonstrate a strategy which can be learned, were presented to the subject. The strategy was not verbalized directly, but could be inferred by the subject, after training had taken place. The experimenter questioned subjects after training to ensure that the subject had been able to identify the particular strategy. Having done so, the subject then continued to perform the task on another set of transparencies developed as a test set.

In the intervention phase, the subject was introduced to two sets of four transparencies which were each divided into four quadrants. Each transparency had a target figure in the middle, which had to be matched to

to the same figure which was embedded among letters in the background of the transparency. In the first transparency, the embedded target figure could be found in the first quadrant (ie. the top left quadrant). In the second transparency, the embedded target figure could be located in the second quadrant (ie. the top right quadrant). The embedded target figures of the third and fourth transparencies were located in the third and fourth quadrants respectively. That is, the embedded target figures were presented in a clock-wise fashion beginning with quadrant one. The target figures of the next four transparencies were located in the quadrants in a counter-clockwise order, beginning with quadrant two.

In the test phase the visual search apparatus was utilized. The subject was again asked to locate the embedded target figure in two sets of transparencies. However, in these two sets, the quadrants were not specified or labelled as such. The subjects received each set consecutively. The sets were given in random fashion to reduce the likelihood of producing an order effect. Two measures were recorded (for the initial set, and the test set of transparencies), elapsed time for search and response, and elapsed search time.

The objective in this part of the second study, was to measure the effect of strategy manipulations upon task performance by introducing an element of strategy (clockwise or counter clockwise). In so doing, the experimenter enabled the subject to think about how the problem could be approached, and to consider an alternative strategy, and subsequently the experimenter might infer that the strategy had or had not been employed by examining the subject performance.

4. Syllogistic Reasoning (SR)

In solving a cognitively complex problem an individual must be able to engage higher level (i.e., executive functions-planning) cognitive processes which include procedures that aid in the solution of a problem. A syllogistic reasoning task is defined herein as an example of a cognitively complex problem.

A syllogism has been defined as a "situation in which the reasoning of formal logic takes place" (Vinacke, 1974, p. 280). The first two statements are called premises, and the third is the conclusion which is said to follow logically from the premise.

Vinacke (1974), has pointed that in syllogistic reasoning four process strategies appear to be involved: determining and discovering what is required; collecting data, evaluating that data for its relevance and significance; and finally, stating the conclusion correctly. As was pointed out earlier, Luria (1973), noted that frontal lobe patients have difficulty in strategic problem solving involving goal-oriented behavior; self-corrective regulatory behavior; and choice behavior. It is assumed herein that solving a syllogistic reasoning problem potentially would indicate the activation of executive or planning strategies.

Sternberg (1979), in researching tasks suitable for measuring component and metacomponent (i.e., executive functions) processing indicated that syllogisms satisfy criteria for inclusion in a battery of tests measuring information-processing functions. The criteria specified by Sternberg in terms of task performance are: it is quantifiable, reliable, demonstrates construct validity and empirical validity.

With this in mind a syllogistic reasoning task was developed. Specifically thirty-two categorical syllogisms (see Sternberg, 1979) were included in the task. In this type of syllogism the subject received two premises, for example, Tina is smaller than Sally; Sally is smaller than Ann, and a conclusion, such as Tina is smaller than Ann. The subject was required to indicate whether the conclusion followed logically from the premise by encircling the word True or False.

The test was divided into four sheets. On the first sheet eight syllogisms were presented in their natural order as described by Fraser (1968). That is in a forward chain requiring no conversions or reordering by the subject. The second sheet also included eight syllogisms, but in order to come to solution, the subject had to reorder one premise. For example, Susan is taller than Ann; Jane is taller than Susan; Conclusion: Ann is taller than Jane. The third set of syllogisms required one premise to be converted. For example, Ann is taller than Alice; Susan is shorter than Alice; Conclusion: Susan is taller than Ann. Finally the fourth set included eight syllogisms in which the subject was required to reorder and convert the premises in order to correctly indicate whether the conclusion follows logically from the premise. For each subject two measures were recorded; the number of errors made and the total elapsed time to complete the entire task. Before concluding a discussion of this task it should be noted that the subjects were assigned each sheet in an order established by a randomized table of numbers to counterbalance the possibility of an order effect confounding performance levels. The objective of including this task in the battery was to determine whether a cognitively complex problem solving test such as this one would correlate with other tests previously identified in the planning battery used by Ashman (1978).

The results of the second study will be presented in two sections. The first section will deal with the simultaneous-successive marker tests, and the planning battery separately. The second section will deal with the strategy manipulations introduced in the two planning tasks (Visual Search and Trail Making).

Results

The Simultaneous-Successive Battery

The means and standard deviations of the four simultaneous-successive tests are presented in Table 5, and their intercorrelations in Table 6. Table 6 shows significant correlations between ASR and DS ($p < 0.001$, df=53, one-tailed test), and MFD and FC ($p < 0.01$), df=53, one-tailed test).

These correlations were submitted to a principal components analysis, and two factors with eigen values greater than 1.0 were extracted. These factors were then rotated according to an orthogonal (Varimax) and an oblique (Promax) criterion. Previous research (Ashman, 1978) also extracted two factors, as did our first study previously mentioned. The varimax is shown in Table 7 and the Promax is shown in Table 8.

The analysis in Table 7 and 8 conform closely to the pattern established in previous research. Simultaneous processing is defined by Figure Copying and Memory for Designs; successive processing by Auditory Serial Recall and Digit Span. This trend confirms the stability of the coding strategies in a college population using the marker test described herein.

The Planning Battery

The means and standard deviations for the four planning tests are shown in Table 9, and the correlations between tests in Table 10. Table 10 shows significant correlations between several planning tests, however, the

Table 5

Means and Standard Deviations of Simultaneous -Successive Marker Tests for the Total Sample (N=55)

Variable	Mean	Maximum Score	Standard Deviation
Auditory Serial Recall	56.95	(72)	11.77
Digit Span	6.89	(9)	1.29
Memory for Designs	42.04	(50)	4.25
Figure Copying	15.04	(24)	3.89

Table 6

Intercorrelation between Simultaneous-Successive Marker Tests (N=55)

	ASR	DS	MFD	FC
Auditory Serial Recall (ASR)	1.000			
Digit Span (DS)	.438	1.000		
Memory For Design (MFD)	.169	.174	1.000	
Figure Copying (FC)	.066	.019	.354	1.000

Table 7

Principal Component Analysis with Varimax Rotation of Simultaneous-Successive Marker Tests (N=55)[1]

Variable	Factor		h^2
	Successive	Simultaneous	
Auditory Serial Recall	832	087	699
Digit Span	848	037	720
Figure Copying	-071	850	722
Memory for Designs	210	788	665
Variance	1.62	1.19	2.81
% of Total Variance	40.60	29.80	70.40

[1]Decimals omitted

Table 8

Principal Component Analysis with
Oblique Rotation of Simultaneous-Successive Market Tests (N=55)[1]

Variable	Factor		h^2
	Successive	Simultaneous	
Auditory Serial Recall	832	028	693
Digit Span	852	-023	726
Figure Copying	131	862	761
Memory for Designs	156	779	631
Variance	1.458	1.356	2.81
% of Total Variance	36.50	33.90	70.40

[1]Decimals omitted

Table 9

Means and Standard Deviations of the Planning Tests (n=55)

Variable	Mean	Standard Deviation
Planned Composition	16.47	4.20
Trail Making	95.23	27.02
Visual Search	24.39	8.44
Syllogistic Reasioning (time)	578.64	289.76
Syllogistic Reasoning (correct)	25.72	4.39

Table 10

Intercorrelations between Planning Tests for the Total Sample (N=55)

	PC	TM	VS	SR	SRT
Planned Composition (PC)	1.000				
Trail Making (TM)	.311	1.000			
Visual Search (VS)	.218	.503	1.000		
Syllogistic Reasoning (SR)	-.135	-.268	-.298	1.000	
Syllogistic Reasoning Time (SRT)	.483	.527	.485	-.174	1.000

r (.05) =.225

syllogistic Reasoning Correct scores did not correlate with any of the other planning tests. This test did not appear to discriminate between subjects as evidenced by the relatively small variance and high scores obtained by the subjects. The test appeared to be lacking in face validity. However, the time taken to complete the syllogistic reasoning task did correlate significantly with the other tests administered in the planning battery.

Table 11 shows the intercorrelations between the simultaneous-successive tests, and the planning tests. As expected the correlations between the two batteries were not significant, with the exception of the correlation between Auditory Serial Recall and Syllogistic Reasoning Time.

A principal component analysis was performed on the two test batteries. Three factors with eigen values greater than 1.0 were extracted, and rotated according to an orthogonal (Varimax) and oblique (Promax) criterion. Table 12 shows Factor I as being defined by Planned Composition, Trail Making, Visual Search and Syllogistic Reasoning Time (the planning factor), Factor II by Auditory Serial Recall and Digit Span (successive factor), Factor III by Figure Copying and Memory for Design.

The solution in Table 12 does establish the existence of three factors, with the simultaneous, successive and planning tests loading on different factors. This conforms to previous results found by Ashman (1978) and to the coding-planning paradigm outlined by Das, Kirby and Jarman (1975). Table 13 confirms the existence of three separate factors, established by factor correlations between the batteries after oblique rotation.

Table 11

Correlations Between four Simultaneous-Successive Tests, Four Planning Tests

Simultaneous-Successive Tests	PLANNING TESTS				
	Planned Composition	Trail-Making	Visual Search	Syllogistic Reasoning correct	Syllogistic Reasoning Time
Auditory Serial Recall	036	214	249	042	433*
Digit Span	024	308	304	194	279
Memory for Designs	211	066	092	119	254
Figures Copying	141	136	048	023	107

* r(.01)=.337

Table 12

Orthogonal (Varimax) and Oblique (Promax) Rotations of
Three Factors following Principal Component Analysis, for the Total Sample (n=55)

Variable	Orthogonal Factors				Oblique Factors			
	I Planning	II Successive	III Simultaneous	h^2	I Planning	II Successive	III Simultaneous	h^2
Planned Composition	697	126	-376	641	733	203	-343	695
Trail Making	719	-341	260	699	685	-274	304	636
Visual Search	630	-419	105	582	588	-362	146	497
Syllogistic Reasoning	-181	657	233	517	-107	651	209	477
Syllogistic Reasoning Time	876	-011	-043	768	892	081	002	801
Auditory Serial Recall	060	831	080	699	163	854	066	759
Digit Span	-150	724	-015	546	-062	724	-039	528
Memory for Designs	-077	219	772	647	-066	213	763	631
Figure Copying	066	010	791	629	052	014	794	632
Variance	2.230	1.998	1.500	5.728	2.192	1.974	1.490	5.656
Percentage of Total Variance	24.77	22.20	16.66	63.63	24.35	21.93	16.55	62.83

[1]Decimals omitted

Table 13

Factor Correlations After Oblique Rotation (N=55)

Factor	1 Successive	2 Simultaneous	3 Planning
1	1.000		
2	0.104	1.000	
3	-0.233	-0.089	1.000

Further Analysis of Visual Search and Trail Making

The purpose of these analyses was to explore the effect of manipulations on task performance. The tasks chosen were the visual search and trail making tasks which had previously been established as part of the planning battery. The intent here was to directly assess the effect of strategy manipulations without referring to the factor structures or individual differences in coding and planning tasks.

Before presenting the results of the effect of task manipulations, it may be useful to present the hypotheses explored. The subjects and testings procedures were outlined in the previous section.

Hypotheses

The hypotheses presented herein are in part an attempt to extend the theoretical formulations advanced in regard to the planning dimension. The objective of the analysis was to test whether strategies can be learned and whether utilization of such will improve the efficiency of performance.

As mentioned previously all subjects completed two experimental tasks involving strategy manipulations. In the Visual Search (VS) task subjects were instructed in particular strategies (clockwise and counter-clockwise) prior to engaging in the task. In the Trail Making (TM) task subjects were not instructed in the use of particular strategies. The VS task was given first and the TM second to all subjects. After testing had been completed the scores were ranked ordered to explore differences in performance between subjects scoring high and those scoring low in the planning dimension. In view of the above considerations the following hypotheses were formulated.

Visual Search:

Hypothesis 1 Subjects will display a significant decrease in search time of the visual search task across trials.

Hypothesis 2:0 Search times across trials will be significantly different between the top and bottom groups.

Hypothesis 2:1 Subjects scoring high on the planning dimension will reach asymptotic performance sooner than those scoring low on the planning dimension.

Hypothesis 2:2 Subjects scoring low on the planning dimension will display variable performance across trials.

Trail Making:

Hypothesis 1: Subjects will display a significant decrease in time taken between first and second half performance on parts A and B of the Trail Making Task.

Hypothesis 2:0 Elapsed time between first and second half performance will be significantly different between the two groups on Part A.

Hypothesis 2:1 Elapsed time between first and second half performance will be significantly different between the two groups on Part B.

Visual Search: Results

In this experiment the strategy manipulations described earlier, were utilized. Elapsed search time scores for all subjects (n=56) were subjected to a 2 (conditions) x 2 (order) x 4 (trials) analysis of variance (repeated measures.) No significant main effect was found in terms of the order of presentation in which the two conditions, (clockwise vs. counter clockwise) were given. A significant main effect for conditions (clockwise and counter clockwise) was found, but had no theoretical significance for this study. The analysis also yielded the anticipated significant main effect over trials ($F=31.97$, df 3/59, $p<.001$). The means for trials collapsed over conditions were: 5.88, 3.51, 3.84, and 2.81. These results which are reported in Table 14, confirmed the prediction that subjects would improve in their performance over trials.

To further test for sub-groups within the total sample, the top and bottom quartiles were extracted from the total group. These scores were then submitted to a 2 (groups) x 4 (trials) analysis of variance (repeated measures). A significant main effect for groups was found ($F=151.08$, df= 1/26, $p<.001$), indicating a significant difference between subject scores in the top and bottom quartiles, and means across trials were 3.30, 1.84, 1.62, and 1.57 for the top group and 8.46, 5.18, 6.07 and 4.06 respectively for the bottom group. (see Table 15)

The analysis also revealed an expected main effect for trials ($F=13.57$, df= 3/78, $p<.001$), and an interaction effect for groups x trials ($F=2.74$, df 3/78, $p<.05$). This interaction is graphically

Table 14

ANOVA repeated measures for all subjects (n=56) in

Elapsed Search Time: Experiment 1

Source	df	MS	F	P
Between				
Order	1	0.129	0.027	0.870
Error	55	4.976		
Within				
Conditions	1	37.978	31.309	0.001
Trials	3	41.524	34.232	0.001
Conditions x Order	1	1.650	1.360	0.306
Trials x Order	3	0.531	0.438	0.747
Conditions x Trials	3	7.087	5.842	0.001
Order x Conditions x Trials	3	1.441	1.188	0.316
Error	159	1.213		

Table 15

ANOVA for Quartile Groups Visual Search Task (N=28)

Source	df	ms	F	P
Between				
Groups	1	417.00	151.08	.001
Error	26	2.76		
Within				
Trials	3	48.72	13.57	.001
Groups x Trials	3	9.84	2.74	.05
Error	78	3.59		

depicted in Figure 1.

It is this interaction effect that is of primary significance for this study, for it suggests that the high and low groups not only differed significantly in their overall search times, but also behaved differently across trials on the visual search task. A visual inspection of the means for the group across trials, (plotted in Figure 1) confirms differences in the trend of the curves.

A trend analysis was therefore carried out. The analysis revealed that the difference in trend between groups is due to significant linear ($F=6.02$, $df= 3.53$, $p<.001$) and cubic ($F=3.89$, $df= 3.52$, $p<.001$) trend components.

To explore these differences, separate trend analyses were carried out on each group. For the top quartile group the analysis of variance revealed significant differences between trials ($F=15.88$, $df=3.52$, $p<.001$) as expected. The trend analysis also revealed a significant linear component ($F=34.46$, $df=1.52$), and a significant deviation from linearity ($F=6.59$, $df=2/52$, $p<.001$). Further examination of Table 16 indicates that the deviation from linearity was primarily due to a quadratic component which was found to be significant ($F=11.79$, $df= 1.52$, $p<001$). Finally the Newman-Keuls test between means revealed a significant difference ($p<01$) between trials 1 and 2, 1 and 3, and 1 and 4, but not between trials 2, 3, and 4.

These findings appear to confirm predictions that the group scoring high on the planning dimension would improve significantly between trials 1 and 2, and appear to reach asymptotic performance levels by trial 2.

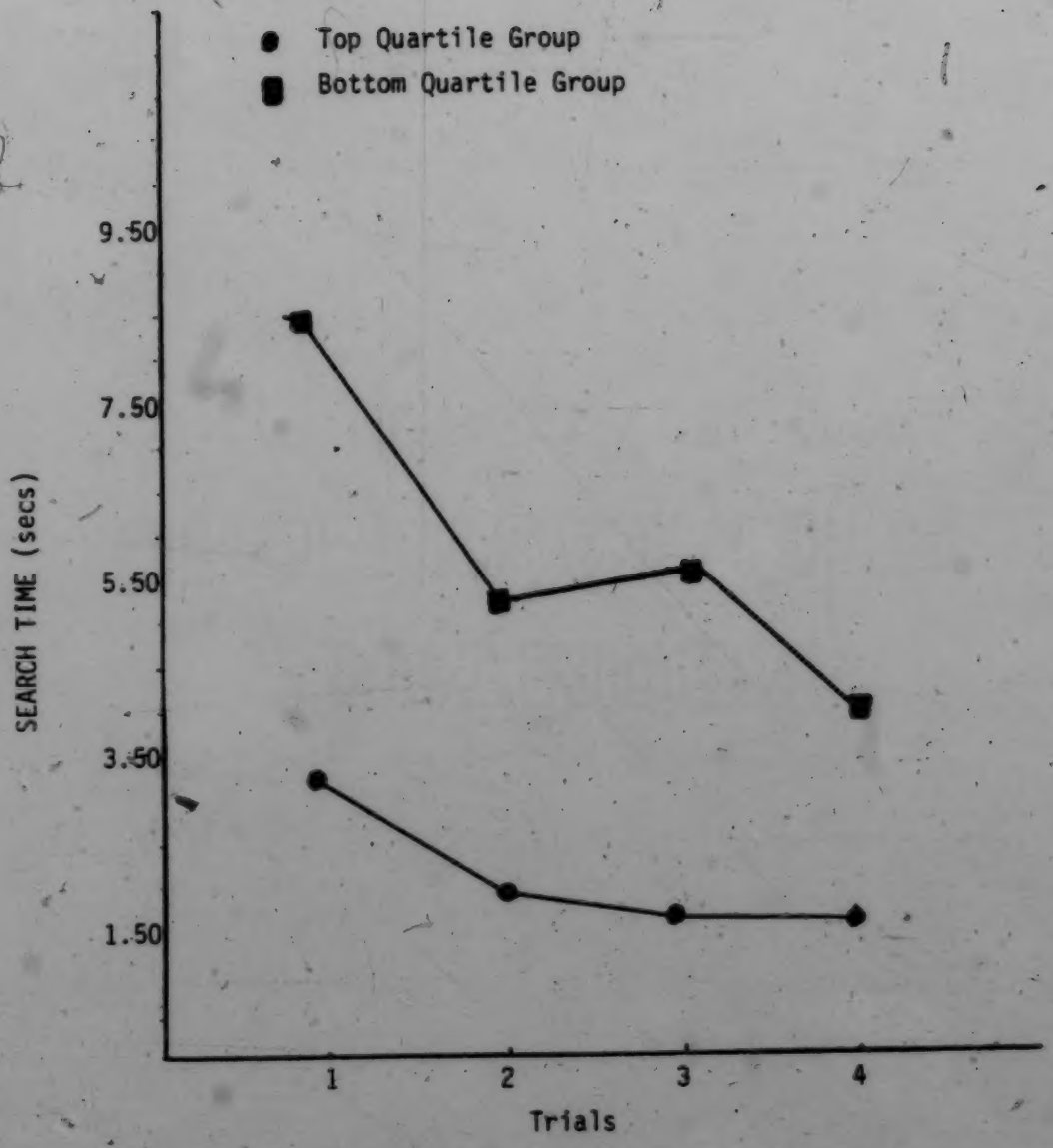


Figure 1. Search time means of groups x trials

Table 16

ANOVA: Trend Analysis on Visual Search

for Top Quartile Group (n=14)

Source	df	MS	F	P
Between	3	9.43	15.88	.000
Linear	1	20.45	34.46	.000
Dev. from Linear	2	3.92	6.59	.002
Quad	1	7.00	11.79	.001
Dev. from Quad	1	0.83	1.40	.242
Within	52	.59		

Table 17

ANOVA: Trend Analysis on Visual Search for Bottom Quartile Group (n=14)

Source	df	MS	F	P
Between	3	49.82	7.94	.000
Linear	1	108.90	17.35	.000
Dev. from Linear	2	20.29	3.23	.047
Quad	1	5.33	0.85	.361
Dev. from Quad.	1	35.24	5.61	.021
Within	52	6.28		

On the other hand the group scoring low on the planning dimension behaved differently across trials. An analysis of variance (repeated measures) and a trend analysis on the bottom quartile subjects are reported in Table 17. A significant main effect for trials was found ($F=7.94$, $df=3.52$, $p<001$). The trend analyses for the low group also revealed a significant linear component ($F=17.35$, $df= 1/52$, $p<001$) and a significant deviation from a quadratic component ($F=5.61$, $df=1/52$, $p<001$). A further calculation revealed that the deviation from the quadratic can be explained by a significant cubic component ($F=9.77$, $1/52$, $p<001$). A visual inspection of Figure 1 appears to confirm these statistical findings. Finally the Newman-Keuls test between means for this group revealed a significant difference ($p<.01$) between trials 1 and 2, 1 and 4, but not between 1 and 3, 2 and 3, or 2 and 4.

These findings suggest that subjects scoring low on the planning dimension do not reach asymptotic performance in this visual search task. The significant linear and cubic components found in their scores across trials suggest an improvement from trial 1 and 2; a levelling off between 2 and 3, and subsequent improvement from 3 and 4. This suggests that subjects in this group learned a strategy and utilized it between trials 1 and 2, but not between 2 and 3, and then utilized it between trials 3 and 4. Finally in view of the strategy manipulations demonstrated by the experiment it appears that this group did not utilize the strategy proficiently across trials. In fact one may question whether this group in fact learned how to utilize strategies in a consistent manner.

These results confirm our expectations that subjects scoring

high and low on this planning dimension would differ in performance across trials. Specifically that they would differ in terms of their utilization and proficiency in adopting the clockwise and counter clockwise strategy manipulations inherent in this visual search task. It was predicted that the high planning group would learn the strategy, plan and use it proficiently as demonstrated by their reaching relative asymptotic performance by the second trial. Similarly it was predicted that the performance of the low planning group would demonstrate considerable variability across trials, thereby not reaching asymptotic performance, and suggesting an absence of learning the appropriate strategy manipulations. Earlier theoretical explanations suggest that this group exhibited deficits in planning.

Trail Making: Results

In the second experiment involving the Trail Making Task, elapsed time was measured for each subject, for Parts A and B. The scores were averaged from all subjects between first and second half of the task, and submitted to a Two-Tailed test of significance of mean differences. A significant mean difference was found for Part A ($t=6.31$, $df=54$, $p<.001$) as well as for Part B ($t=6.88$, $df=54$, $p<.001$). This result confirmed the prediction that subjects would demonstrate a decrease in elapsed time from the first half to the second half of each part of the Trail Making task.

The total scores from each subject were summed across Parts A and B and rank ordered to extract top and bottom quartiles. The scores on Part A and B for the two groups was then submitted to a 2 (groups)x 2 (parts) x 2 (halves) and analysis of variance repeated measures. The results in Table 18 reveal an expected significant main effect between groups ($F=143.10$, $df=1/52$, $p<.001$), between Part A and B ($F=10.91$, $df=1.52$, $p<.002$) and between the first and second halves of the tasks ($F=21.77$, $df=1/52$, $p<.001$). The mean elapsed time for the two groups, on Parts A and B, and between first and second halves of the task are reported in Table 19.

In order to determine more specifically the nature of the group differences on <u>each</u> part of the Trail Making task further analyses were carried out.

<u>Part A</u>

The scores on Part A for the two groups were submitted to a 2 (groups) x 2 (halves) analysis of variance repeated measures. The results in

Table 18

ANOVA repeated measures on Trail Making-Part A & B

for top and bottom quartile groups (n=28)

Source	df	MS	F	P
Between				
Group	1	95.83	143.10	0.001
Part (A&B)	1	7.30	10.91	0.002
Group x Part	1	2.29	3.33	0.074
Error	52	0.67		
Within				
Halves	1	10.44	21.77	0.001
Group x Halves	1	1.16	2.42	0.126
Part x Halves	1	0.04	0.07	0.786
Group x Part x Halves	1	0.97	2.01	0.162
Error	52	0.48		

Table 19

Means and Standard Deviations of

Trail Making Experiment for Top and Bottom Quartile Groups (in sec.) (n=28)

Variable	Mean	Standard Deviation
Part A		
Top-First half	3.24	.57
-Second half	2.58	.42
Bottom		
-First half	4.79	.91
-Second half	4.16	.96
Part B		
Top-First half	3.62	.66
-Second half	2.66	.55
Bottom		
-First half	5.36	.85
-Second half	5.18	.95

Table 20 reveals a significan main effect between groups ($F=11.24$, $df=1/26$, $p<.002$). Finally, the result of note is the interaction effect found between groups x halves ($F=17.63$, $df=1/26$, $p<.032$), suggesting that the high and low planning groups behave differently in their performance from the first to second half in this task. The means for the groups are plotted in Figure 2. A two-tailed test for the high group means reveals significance ($t=2.31$, $df=13$, $p<.05$), however, such is not the case for the low group means. This may suggest that subjects scoring high on the Trail Making test in all likelihood established a strategy and utilized it proficiently. The subjects scoring low on the Trail Making test, on the other hand, appeared not to see a pattern developing in the task or did not exercise a strategy proficiently. These statements are hypothetical, but confirm theoretical explanations advanced on the planning dimension.

Part B

In Part B of the Trail Making task the top and bottom quartile scores were extracted and the data submitted to a 2 (groups) x 2 (halves) analysis of variance repeated measures. A main effect was observed between groups ($F=60.06$, $df=1/26$, $p<.001$), and between first and second halves ($F=10.68$, $df=1/26$, $p<.003$). However, the analysis which is reported in Table 21 did not reveal an interaction effect. That is, the two groups were not significantly different from the first to second half in terms of improvement of elapsed time. This result is not consistent with the hypothesized prediction. An explanation might be that although the low group scores were higher (see Figure 3) this group did, in fact, recognize a pattern developing, thereby utilizing a strategy in this task, making improvement earlier and maintaining this improvement.

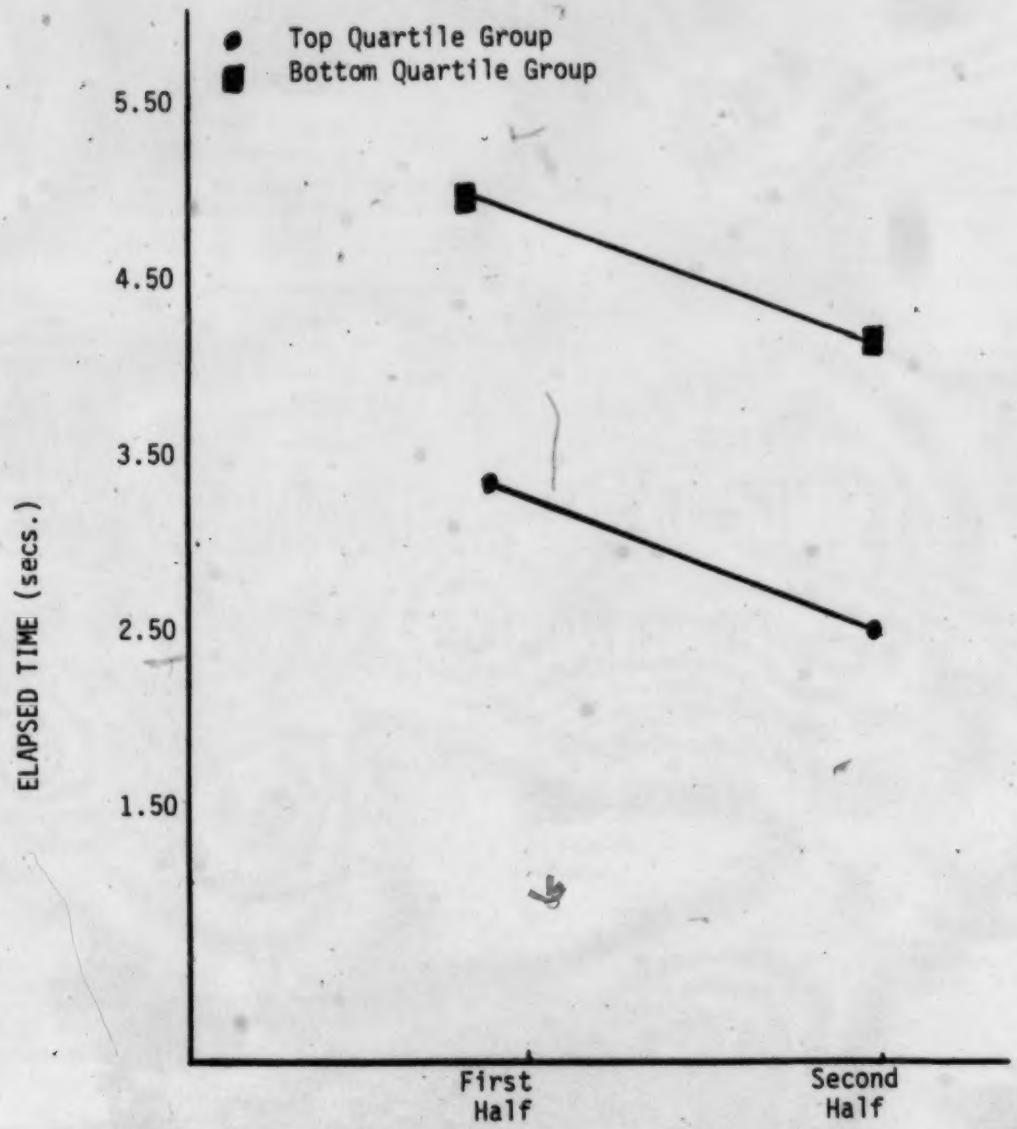


Figure 2. Elapsed time means of groups x halves (Trail Making-Part A)

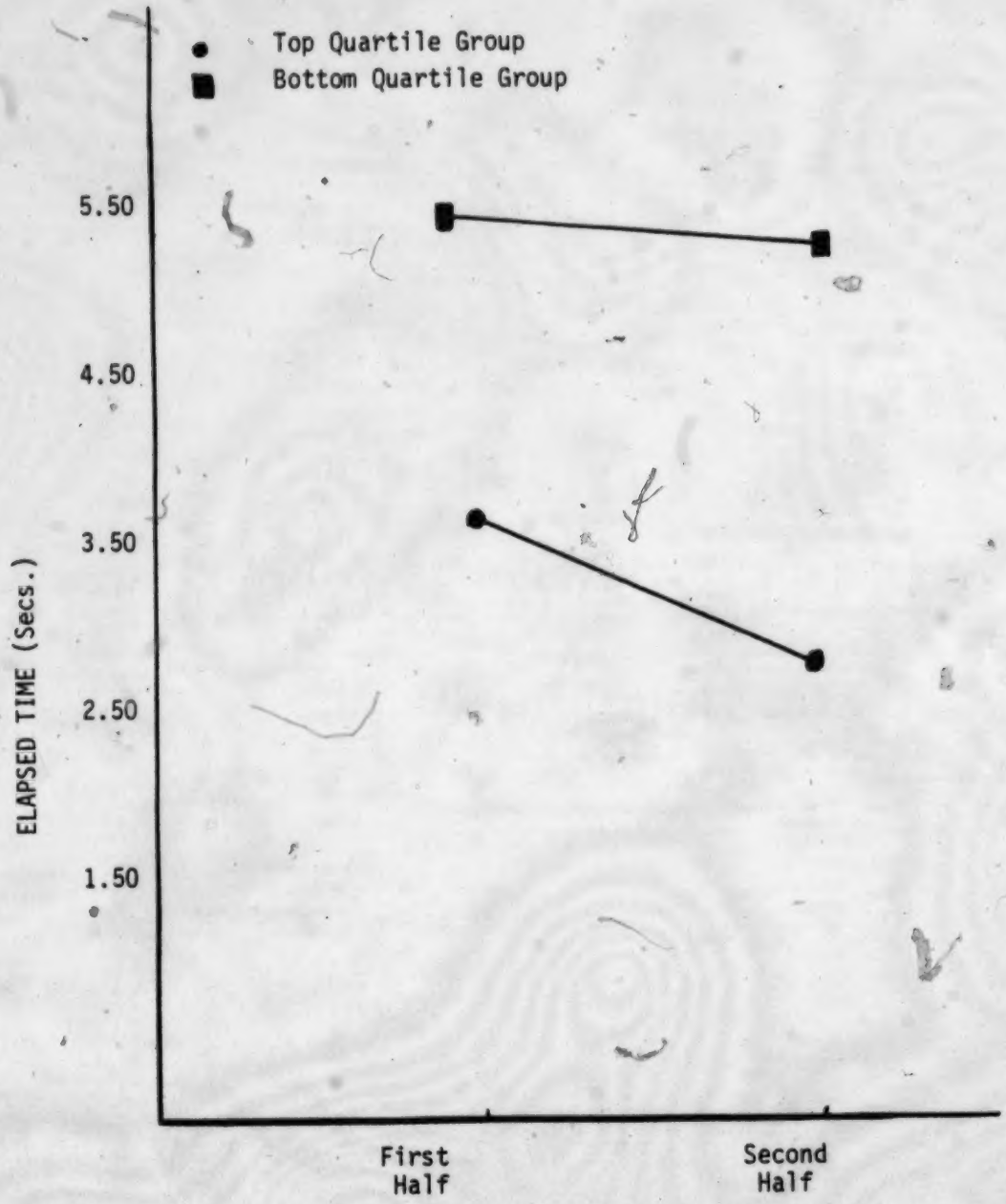


Figure 3. Elapsed time means of groups x halves (Trail Making-Part B)

Table 20

ANOVA repeated measures on Trail Making PART A

for top and bottom quartile groups (N=28)

SOURCE	df	MS	F	P
Between				
Groups	1	63.64	83.04	.001
Error	26	.77		
Within			11.24	
Halves	1	4.63	5.15	.002
Groups x Halves	1	2.12		.032
Error	26	.41		

Table 21

ANOVA repeated measures on Trail Making - Part B

for top and bottom quartile groups (n=28)

Source	df	MS	F	P
Between				
Groups	1	34.41	60.06	.001
Error	26	.573		
Within				
Halves	1	5.85	10.68	.003
Groups x Halves	1	.004	0.008	.929
Error	26	.55		

CHAPTER V

Study 3: Problem Solving

In our earlier discussion of planning and problem solving, it was suggested that the executive function of cognition is activated in problem solving, specifically that problem solving tasks are able to demonstrate the role of planning in higher-order thought processes.

As previously mentioned the cognitive process of planning was discovered by utilizing the Visual Search (VS) task among others (Ashman, 1978). Having already demonstrated that the VS task has high loadings on a factor of planning which was orthogonal to coding: that it reflects individual differences; and is susceptible to stategy manipulations, it remains to be seen if individual differences on this measure would relate to differences which involve higher-order problem solving. One would predict this to be the case, that in fact the cognitive process of planning evident in a VS task, would also be evident in a higher-level problem solving task. Subsequently, one could expect high and low performance levels on one task would also be evidenced on the other. Furthermore, low performance on a problem solving task should reflect a deficit in planning and strategic behavior.

Solving a problem involves organizing and structuring information which activates planning and coding functions. In order to solve a problem, the subject must be able to know what is required in the task, have a plan or strategy by and on which to operate, have an orientation or attitude set which will

facilitate working towards a goal, be able to control and regulate behavior according to the plan, and finally, verify that the intention of the plan is carried out.

As pointed out previously low scores on tasks measuring planning behavior may be due to any or all of the following: the inefficiency of realistic self-evaluation performance, a failure to monitor, check and register ongoing behavior, inefficient use of control processes, ineffective strategic transformations of input, and a lack of feedback to response correcting behavior. In short subjects generally deficient in planning demonstrate inadequate higher-order information processing skills.

In this study, the problem solving behavior of good and poor 'planners' as indexed by their visual search scores, is examined.

The specific objectives of this study are:

1. To investigate the relationship of subjects' scores on two tasks involving planning behavior, one primarily involving visuo-perceptual functioning and the other logico-rational functioning.
2. To explore the qualitative differences in the strategies utilized for problem solving between the good and poor 'planners.'

Hypothesis

The hypothesis is advanced to attempt to test the generality of the assumptions of the cognitive process of planning, by examining the relationship between scores on a Visual Search task and a

higher-order problem solving task (Mastermind Game).

It is anticipated that subjects scoring in the top and bottom quartiles on the VS will differ significantly in performance on Mastermind. Specifically it is predicted that subjects scoring high on the VS will take fewer trials to solutions than those scoring low.

Method

Subjects

Sixty first year students enrolled in four programs at a community college acted as volunteer subjects. These programs typically draw students from a cross-section of socio-economic status. The students ranged from 18 to 30 years in age, and had a mean age of 22.42. The sample comprised an equal number of males and females.

Tests and Procedures

The two instruments used were the standard version of the Visual Search task and the Mastermind task. The VS was administered to all subjects. Subsequently, the top and bottom quartile scores were extracted leaving a sample size of 30 subjects. These subjects were then administered a Mastermind task.

1. Visual Search Task

The standard version developed by Ashman (1978) was used in this study. In this task subjects were required to search for a duplicate match of a target figure. The matching figure was embedded among geometric, letter and numerical shapes in a field.

Each field was constructed on an overhead transparency and then inserted in the Visual Search viewing apparatus. The apparatus permitted accurate timing of the subjects search time in locating the duplicate match of the figure. A description of the procedure, and a copy of a field are in Appendix A.

2. Mastermind Task

This task was developed by Parker brothers, and involves problem solving strategies. It meets the criterion of being: "subject-matter free" and well structured. Davis (1973) defines a problem solving task as a stimulus situation for which an organism does not have a ready response. The Mastermind task fits this criterion.

In this task the experimenter set up a line of coloured code pegs (which were out of the visual range of the subject) in shielded holes located at the end of the de-coding board. The subject was required to duplicate the exact colour and position of the hidden code pegs set up by the experimenter. The 6 colour-4 hole version of the Mastermind task was used. The 4 colours making up the code for each trial were randomly selected by the experimenter, not allowing for 2 or more code pegs of the same colour. Three trials were given to each subject thereby reducing the likelihood that responses would be spuriously affected by chance factors. More trials may have been even more effective, however, limited time available to subjects did not make this possible.

After selecting the coloured code pegs (i.e. blue, brown, red, orange, green, yellow) each subject placed a row of four code pegs into the de-coding board. The experimenter then placed a black peg adjacent to the row if the subject had correctly chosen one of the colours and it was also located in its proper position. A white peg was placed if the subject had chosen a colour identical to one of the code pegs in the shielded holes, but had not placed it in the correct position. If the subjects peg did not match the experimenters in colour or position, the key peg holes adjacent to the row was left vacant. When the subject duplicated the hidden code in the shielded holes, the experimenter placed 4 black key code pegs.

The number of rows taken to break the code for each game or trial was recorded as was the amount of time taken to complete each row. The instructions and hidden colour coded pegs for the three games or trials are found in Appendix J. Finally any verbalization given by subjects during the task were recorded.

Results

The scores of all 60 subjects on the visual search task were rank ordered and grouped into four hierarchical quarters or quartiles. The mean and standard deviations (in seconds) for each quartile group was then calculated and are reported in Table 22. The mean comparisons between the top and bottom quartile groups revealed significant differences ($T=9.81$, $df=28$, $p<.001$).

Table 22

Mean and Standard Deviation of Visual Search
Tests for Quartile Groups for Total Sample (N=60)

	Means	Std. Dev.
1st Quartile Group	8.86	1.56
2nd Quartile Group	11.73	.51
3rd Quartile Group	13.86	.64
4th Quartile Group	17.35	2.97
TOTAL GROUP	12.95	3.55

The top and bottom quartile subjects were then required to solve the Mastermind Task. The row scores for each trial for the two groups, and the time per row scores for each trial are reported in Table 23. These scores were then submitted to a 2(group) x 3(trials) analysis of variance, repeated measures. Table 24 indicates an expected significant main effect for groups ($F=9.25$, $df=1/28$, $p<.005$). The same analysis did not yield a significant main effect for trials, or the interaction between groups and trials. This was also expected in that subjects did not differ significantly between trials indicating perhaps that the task measured differences consistently.

The time per row scores were also submitted to a 2(groups) x 3(trials) analysis of variance, repeated measures. Table 25 indicates that no significant main effect for groups or trials was found. This suggests that in this task, time was not a variable that discriminates between the groups, and that solution time did not change significantly across trials.

Qualitive Analysis

As expected subjects scoring high on the planning dimension took fewer rows to break the code in the Mastermind task, than did subjects scoring low on the planning dimension. It would appear plausible to suggest that subjects scoring low on the visual search task exhibited more deficits in planning behavior than those scoring high, as evidenced by their performance in a complex problem solving task. It can only be speculated at this time why the groups differed in performance. However, the verbal reports

Table 23

Mean comparisons of Master Mind Row scores across 3 trials for two groups (N=30)

Variable	Group Means: High 1	High 2	High 3	Low 1	Low 2	Low 3
Rows	6.46	5.40	5.20	9.67	8.73	9.27
Time/Row (Sec.)	52.56	51.80	51.87	53.14	59.68	56.09
Total Rows		17.06			26.45	
Total Time (Sec)		937.00			1721.33	

Table 24

ANOVA repeated measures for Master Mind Rows

across trials for two groups (N=30)

Source	df	MS	F	P
Between Groups	1	280.89	9.252	.005
Error	28	30.36		
Within Trials	2	8.61	1.05	NS
Groups x Trials	2	1.63	.209	NS
Error	56	8.19		

TABLE 25

ANOVA repeated measures for Master Mind Time across trials for two groups (N=30)

Source	df	MS	F	P
Groups	1	401.78	.130	NS
Error	26	3091.13		
Within Trials	2	63.63	.121	NS
Groups x Trials	2	100.11	.190	NS
Error	56	525.69		

of subjects recorded during the problem solving task may provide some clues. These records also provide data for further exploration in terms of the planning dimension. The records indicate a distinct set of personality and cognitive differences between these two groups.

(a) Superstitious Behavior

In terms of personality differences, some of the low level problem solvers engaged in superstitious behavior as evidenced by the following responses:

"red was good to me last time."

"people usually prefer brighter colours."

"I don't like dull colours."

(b) Value of Reasoning

Bloom and Broeder (1974) in examining lower aptitude students also found that they are "inclined to take the view that in solving problems, reasoning is of little value and that either one knows the answer to a problem at once or one does not." (p. 21).

A similar attitude was in evidence in this study with the low level problem solvers. Several subjects made the following responses:

"there must be a trick to this."

"I can't do this kind of thing, it doesn't make any sense."

"I've just about tried everyone of these colours already."

Bereiter and Engelman (1974) also point out that low aptitude subjects usually believed that "answers had to be grasped at once, or they were inaccessible." (p. 34).

(c) Use of Feedback

The problem solving approach exhibited by those scoring low on the planning dimension is further illustrated by their placement of pegs during the game. Some subjects would appear to be fixated on a certain singular colour and would continue using it in spite of the negative feedback, which indicated its inappropriateness. Similarly, subjects used the identical colour combinations and positions several times within one trial, indicating a lack of effective monitoring and checking strategies. A general lack of systematic strategic behavior was found to be present in low problem solvers.

Underwood (1978) in discussing strategies notes that limits on the ability to perform a task effectively are threefold: failure to use the appropriate strategy, inadequate proficiency and limited capacity. It is unlikely that subjects had difficulty due to limited capacity; however, our records do indicate inappropriate and/or an absence of strategic behavior. Feedback from the experimenter is given after each row placed by the subject, however subjects who are low in problem solving skills do not adequately recognize or utilize the feedback, since they do not shift their responses. Planning is certainly involved in the selection of strategies. In this particular task, the effective strategies are: formulating hypotheses, exploring alternatives, monitoring feedback and finally, verifying and rejecting hypotheses. There is very little evidence from observation or the verbal reports of poor players in Mastermind to indicate the presence

of these strategies.

The approach to problem solving taken by the subjects scoring high on the planning dimension is distinctly different. These subjects demonstrated evidence of the appropriate formulation and utilization of strategic behavior. Several subjects would place colours not used in their row next to the board as a visual reminder and would discontinue the practice when the colour code had been broken.

(d) Presence of facilitatory vocalization

Another index of strategic behavior described by Flavell (1970) and confirmed in observation in this study is the presence of vocalization during presentation of items. One subject responded "I'll have to start talking to myself. I find it helps." This group also appears to benefit from feedback as evidenced by this remark: "I won't make that mistake again in the next row." The subject is obviously monitoring and checking his behavior. The high group also demonstrated the recognition of the utility of prior knowledge: "This reminds me of a math course I took, it involved permutations." Underwood (1978) has termed this behavior as relatedness search in which the subject searches in memory for items related to a given stimulus situation.

In conclusion, the evidence of strategic behavior provided by cognitive learning theorists suggest that perhaps there is one strategy or master plan which facilitates the acquisition and use of all other strategies. Evidence of higher order strategy is best exemplified by a response made by a subject in the high planning group. "Now I've developed a strategy. First find the colours---by process of elimination. I place each colour next to the board for reference. I just can't play a game without understanding the systems involved."

CHAPTER VI

Summary & Conclusions

The basic purpose of this research was to explore the planning function of adults within an information processing framework. The strategy employed towards that end involved the selection of tasks, especially those which had been used to test frontal lobe functions, postulated by Luria to be responsible for the planning and programming of behavior. Luria used the clinical method to derive a set of tests which defined a frontal lobe syndrome, and then used the common task demands in these tests to define the deficient cognitive process which in this case was planning. The purpose of these tests was to establish dysfunctions unique to patients with frontal lobe damage. The final battery of tests for planning was determined by factor-analytic work, and the invariance of the planning factor was established across groups with normal and subnormal intelligence. (Ashman, 1978; Das, 1980).

For the purposes of the present study, especially in Study 2, the battery of planning tasks was modified and a new task (syllogistic reasoning) was added. Correlational and factor analyses were then constructed to determine the relationships among the tasks. These procedures resulted in a set of tasks which were fairly reliable, statistically independent, purported to possess construct validity, and consistently provided measures of individual difference.

Secondly a number of experimental "treatments" were built into the study to extend the theoretical underpinnings of the selected tasks, thus allowing for stronger interpretations of the planning dimension under study.

Thirdly, analysis of variance techniques were used to isolate potential individual differences in planning dimension. In summary, the primary question addressed concerned:

(i) the replicability of previous findings,

(ii) the use of additional tasks, to measure the planning functions;

(iii) the induction of treatments to extend theoretical formulations; and finally the adequacy of one of the planning tasks to predict competence in a complex problem solving task such as Master Mind.

Replication of the Planning Factor:

In order to distinguish the coding function from the planning function all planning tasks were factor analysed along with the battery of tasks previously found to describe simultaneous and successive processing.

The principal component factor analyses established planning as an orthogonal factor to coding. The statistical analyses as such did not establish the independence of these processes. The independence of planning from coding came from theoretical formulations of the information integration model of Das et. al (1975) which has as it's basis the clinical work of Luria. Luria established functionally independent cortical areas for the cognitive processes of planning and coding.

These results replicated the findings of Ashman (1978) and thereby appear to re-affirm the identification of planning as a cognitive process as suggested by Luria's clinical observations of Block 3 functioning. The tasks found to consistently contain high loadings on a factor identified as planning were the Visual Search, Trail Making and Planned Composition. Furthermore, the syllogistic reasoning time measure taken from the cogntive learning research literature also loaded highly on the planning factor.

Treatments

Results from the treatments built into the studies established consistent and stable differences between subjects scoring high and low on tasks previously established as measuring planning behavior. These treatments thereby extended the theoretical underpinnings of the selected tasks, thus allowing for stronger interpretations of the planning dimension.

Specifically training in the clockwise and counterclockwise strategies resulted in differential performance between groups scoring high and low on the planning dimension, thereby reflecting differences in utilization of the strategy and the proficiency with which it was used.

It can be hypothesized that the inability to successfully activate the appropriate planning functions required by the task

resulted in differential performance between groups. Atkin (1978) in a similar study found evidence to support the notion that individuals low in problem solving ability had difficulty in using newly learned information to solve complex problems. Atkin postulated that this difficulty was due to "the inability to successfully activate the appropriate control processes (executive function) that resulted in low scores on problem solving."

It seems likely therefore that differential performance on tasks utilized in our study were due to planning differences. These differences are likely to occur at the stage of either choosing an appropriate plan or the efficient use of that scheme or program in carrying out the plan. In support of the latter, it has been suggested that poor performance can be explained in terms of ineffective sequencing of a plan. Specifically, it entails the inability to generate all successful steps in a plan, and an ineffective orientation towards the formation and execution of a plan.

Complex Problem Solving (Mastermind)

Having determined individual differences on a planning task derived from the clinical work of Luria, and found through factor analytic methods (Ashman, 1978, Das, 1980), the logical next step would be to determine whether performance on a planning task would relate to performance on a complex problem solving task. Our results support this predicted relationship.

Previous research reported earlier, has established that "higher level" cognitive processes are involved in complex problem solving. The existence of this executive functioning has been

reported in the neuropsychological and cognitive learning research literature. In line with these our study discovered that subject's scores on a planning task were positively related to scores on a problem solving task. Therefore by inference it may be suggested that differences in problem solving can be attributed to planning differences. Furthermore, as suggested by Flavell (1978), Brown (1978), Sternberg (1979) and others, deficits in problem solving may originate in defective planning strategies. Observations reported in our study tend to support this notion.

It appears that one of the differences which may exist between high and low problem solvers, is perhaps the absence or presence of planfulness. It would appear plausible to suggest that the strength of this planning strategy distinquishes between these two groups.

In summary it appears that differences in complex problem solving performance may be due in part to the ability to initiate and maintain a plan of action. This finding is consistent with previous formulations of the information integration model of Das et. al (1975).

Limitations and Implications for Future Research

1. The utility of the third study is limited in that the indicators associated with planning control processes were obtained only in a very general manner. Although anecdotal records did provide evidence of differential strategic behavior, it could not be ascertained which specific strategies facilitated problem solving behavior. One might more directly establish the existence of planning functions by operationalizing its component functions and

train individuals in the usage of such in problem solving tasks.

2. The utility of the findings in our studies are limited in that planning as a higher-level cognitive process is diverse and complex in nature, and studies 2 and 3 are at best a modest advance in this area of research.

3. Finally a limitation of this study is that cognitive information processing differences alone may not be sufficiently sensitive to ascertain differences in performance on measures utilized. Therefore the inclusion of a number of personality and motivational factors would be recommended in future studies.

Implications for Research

One of the problems in research on higher-level cognitive processes is the diverse descriptors used to identify them (ie. metacomponents, executive, homonculus, control processes). In order to advance beyond this state of confusion it may be useful to attempt to theoretically and empirically identify a hierarchy of possible strategies involved which may differ in strength from person to person as Underwood (1978) has suggested. The author has speculated that "planfulness" may in fact be the "central strategy" in higher-level cognitive processing which may "facilitate the acquisition and use of all other strategies." (p. 441). Similarly, Brown (1974) has suggested that the strategy of constructing a strategy or "a plan to make a plan" may in fact be at the top of any hierarchy of strategic and intentional behavior. Brown and Campione (1979) in their work with moderately retarded groups have proposed that:

> "if one statement could summarize our conclusion it would be that it is not the presence or availability of the components of the target activity that is at fault in the retarded child, but rather it is the ability to select, modify, and sequence these components into an overall plan of procedure and evaluate the effectiveness of the approach selected. (p. 149).

Evidence of strategy differences in these populations has been provided and deserves further exploration. It is hoped following these leads that research into the nature of planning as a metacomponent and as an individual difference variable will clarify the notion of planning and ultimately lead to instructional programs to remediate deficits in planning behavior.

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APPENDIX A

Directions for the Visual Search Task

Testing procedure

The procedure followed for administration of the Visual Search task was the same for each subject in Study 2 and Study 3. The directions to testees were played on a cassette tape recorder, and were as follows:

"This is a test of how quickly you can find one pattern in a group of similar ones. We're going to use this box and electronic timers attached to it.

"I have a number of transparencies which I am going to place inside the box and when you turn the light on, you'll be able to see them through the red screen. But first, let me explain how to work the box.

"When you push down on the black switch, and hold it down, the light will come on and the timers will start. There is one rule you must remember, you must hold the button down or the light will go off. Try it. Push the button down and then take your finger off it and see what happens. (Pause) So to keep searching the transparency you must keep your finger pressing down on the black switch.

"There is another way to turn the light off. You can do that by Pressing down quickly on the red screen using the same finger you used to keep the black switch down. Let me demonstrate this for you. (Tester demonstrates) Now you try it. Turn the light on then switch it off by pushing down on the red screen quickly. (Pause)

"Let me show you one of the transparencies. (Tester inserts a sample into the apparatus). This one has nine patterns on it which are letter, numbers and geometric shapes, plus a circle in the middle. On all of the transparencies there will be a copy of the shape which appears in the circle, somewhere else in the field. Your task is to point to the shape in the field which is exactly the same as the pattern you will find in the circle. Do this as quickly as you can when the

light comes on. The shape you will be looking for is always different on each transparency, and is exactly the same as the one in the circle - it's never twisted around or distorted.

"Let us try a practice one, but first let me review the directions. When the transparency goes into the box, push down on the black switch and search for the copy of the shape you will find in the circle. Only when you have found the copy, lift your finger off the button and push down on the screen towards the copy. In effect you'll be pointing at the copy just below the screen.

"Are there any questions?" (Tester inserts practice transparency into the aparatus)

When the practice is complete, the tester resets the timers and places the first trial slide into the box. Transparencies were presented in random order, and times were recorded after each trial. The correlation between the two measures (Search Time and Response Time) was high ($r=0.974$, significant at the 0.005 level.)

Two Examples of Visual Search Transparencies (x 0.5)

APPENDIX B

Instructions for Visual Search Experiment

1. Sample Sets

A sample transparency was selected and shown to the subject without the aid of Visual Search Box Instructions were given as follows:

"I am going to show transparencies similar to this one, and each will have something in the centre of it (Experimenter points to stimulus target) I want you to find another one, somewhere else on the paper exactly like the one in the circle, and point to it. Go ahead."

The experimenter that subjects clearly understood the directions before demonstrating the operational procedure of the USB. The experimenter then continued as follows:

"I am going to demonstrate how this box will be used in helping you to locate the figures on the transparency. I'm going to put each transparency into the box like this (transparency placed within the slot, covered with a white sheet on top of it) Then I want you to press down on this button to turn the light on and hold the button down until you find one that is the same as the one in the center (the sample transparency already familiar to the subject was used). When you find the one you want, use the same finger to quickly press down on it (this will also turn the light out).

After having gone through one trial the subject was reminded of two important points.

1. The subject must keep the button pressed while searching for the target. The tendency is often to let go quickly, but since this will stop the timer, it was made clear that the subject was not to lift his finger until he is ready to press down (point to) the target.

2. The subject must use the same hand to press the button, and point to the target.

Between each trial, the experimenter pushed the reset button in order to set the timers back to zero.

In order to ensure that the subject was comfortable with the use of the VSB, two sample transparencies were used.

2. Training Sets

Following the sample sets each subject was given a clockwise (CW) or counter-clockwise (CCW) transparency. The order of presentation was altered from one subject to the next.

Assuming that the subject first received the CW set, the instructions verbalized by the experimenter continued. "See this transparency - it's divided into four parts. I'm going to show you four transparencies in a row, and in each one I want you to point to one which is the same as the one in the center. (Experimenter pointed out the target stimulus).

The subject was then asked "did the ones you pointed to come in any particular order?" The subject usually showed the experimenter or used the CW or CCW terminology to describe the sequential order.

Although further research into planning should be carried out, one of the problems in researching this area has been the difficulty in experimentally isolating the specific processes involved in planning. To that end Sternberg (1979) has devised two methods that may provide insight into planning behavior.

The first method is identifed as "structural precuing" and the second as "mixed-versus-blocked trials." In "structural precuing" two conditions are presented in which subjects receive varying amounts of information required for solving a problem. Subsequently subjects receive the full problem in the second part of each trial. The dependent measure which is labelled "strategy planning time" is attained by calculating the difference in elapsed time to achieve criterion between these two conditions. In the second method problems are presented either in blocked form or in mixed form. In blocked form, the trials involve problems with structures that are identical. However, the problems presented in mixed form vary in structure thereby requiring different strategies. The dependent measure also labelled "strategy planning time" is calculated "by subtracting for each subject mean blocked-trial time from mean mixed-trial time" (Sternberg, 1979, p. 261).

In regard to subject populations, continued investigation is necessary to establish group differences in planning behavior. Since the literature on age, retardation, and aptitude has established replicable and consistent cognitive differences, research must be expanded to include group differences between normals and retardates, adults and young children, and adults of differing intellectual levels.

If the subject did not recognize a specific pattern, the experimenter used the transparencies again, and drew attention to the pattern.

Once having established that the subject understood the notion of the pattern, the other Training set was administered in like fashion.

3. Test Sets

"Now we are going to use the machine again. Do you remember how?" At this point another sample was given and the instructions received.

APPENDIX C

Directions for the Trail-Making Test

Part A:

Look here. In this test your task is to draw lines between the numbers on the page in the correct order - from 1 to 2, from 2 to 3, from 3 to 4 and so on, until the end is reached.

"If you realize you have made a mistake, go back and cross it out quickly (you do not have to erase the lines) and then go on in the correct way."

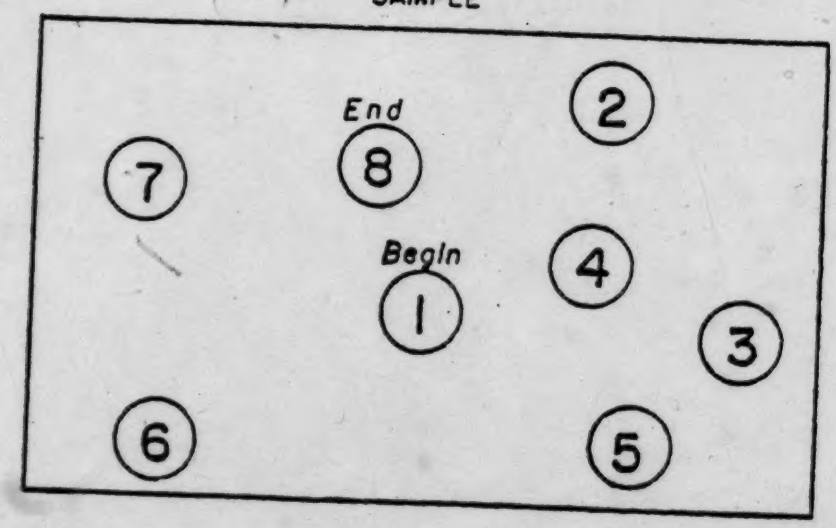
Part B:

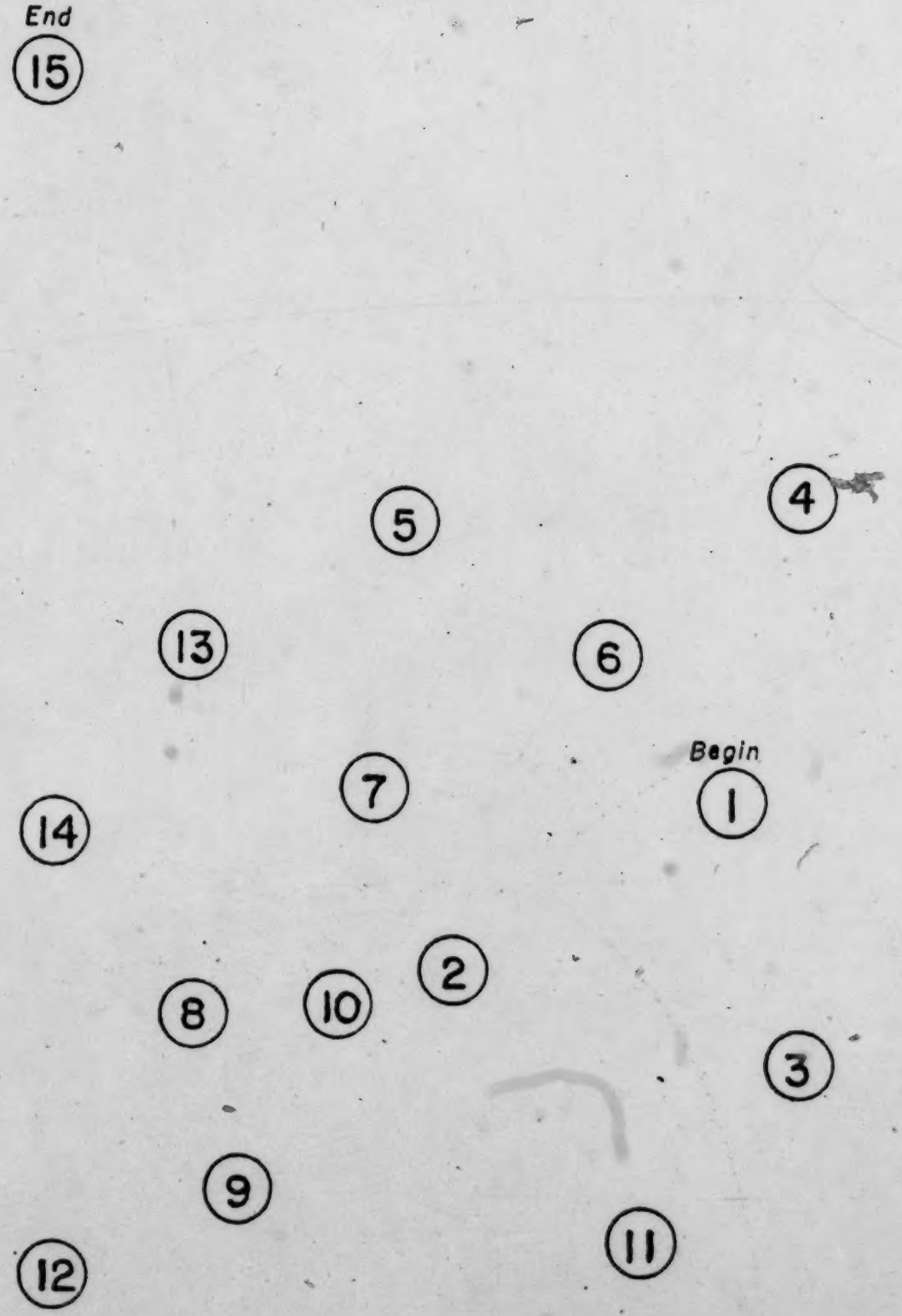
"This part is similar to the other except there are both numbers and letters. In this test, your task is to draw a line from 1 to A, from A to 2, from 2 to B, from B to 3 and so on in this way until you get to the end. Work as quickly as you can. If you make an error, cross it out and go on quickly."

INTERMEDIATE FORM
TRAIL MAKING

Part A

SAMPLE




End
15
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Begin
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14
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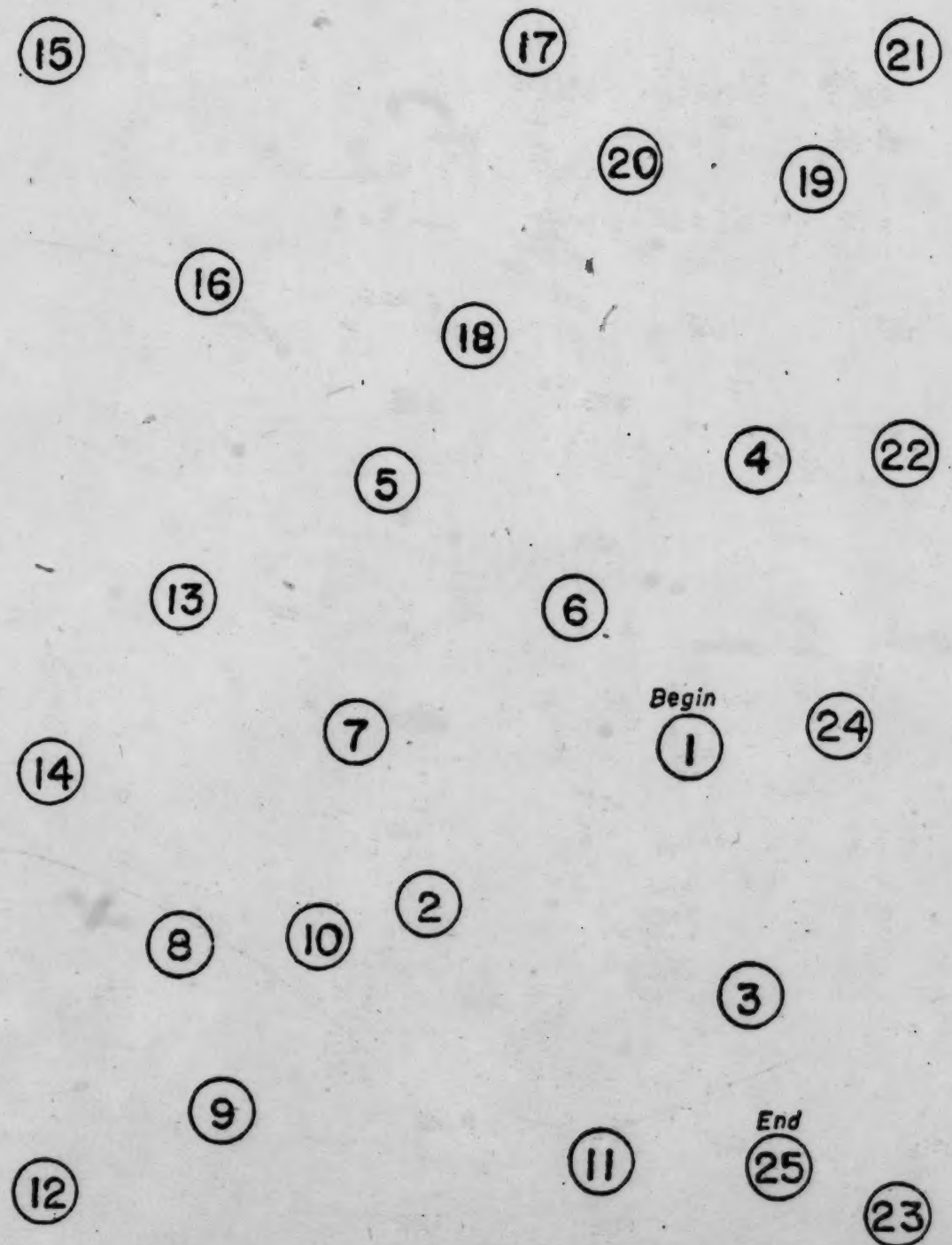
11
12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End
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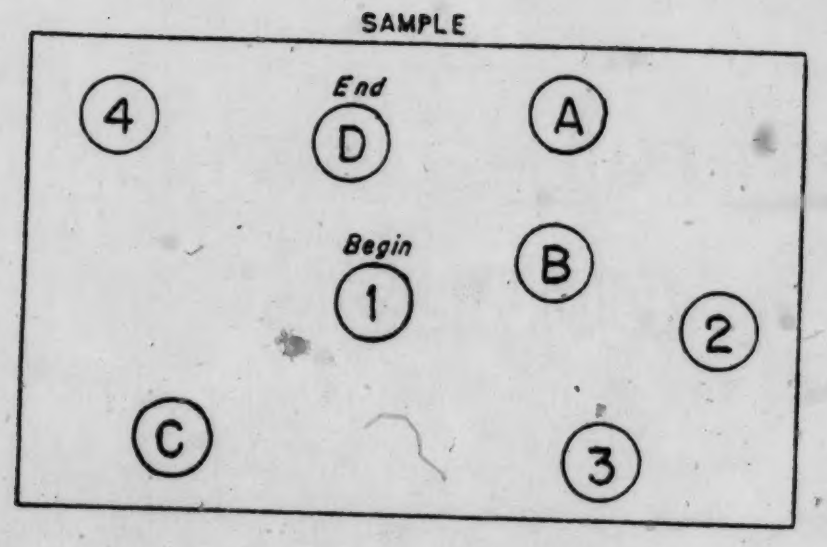
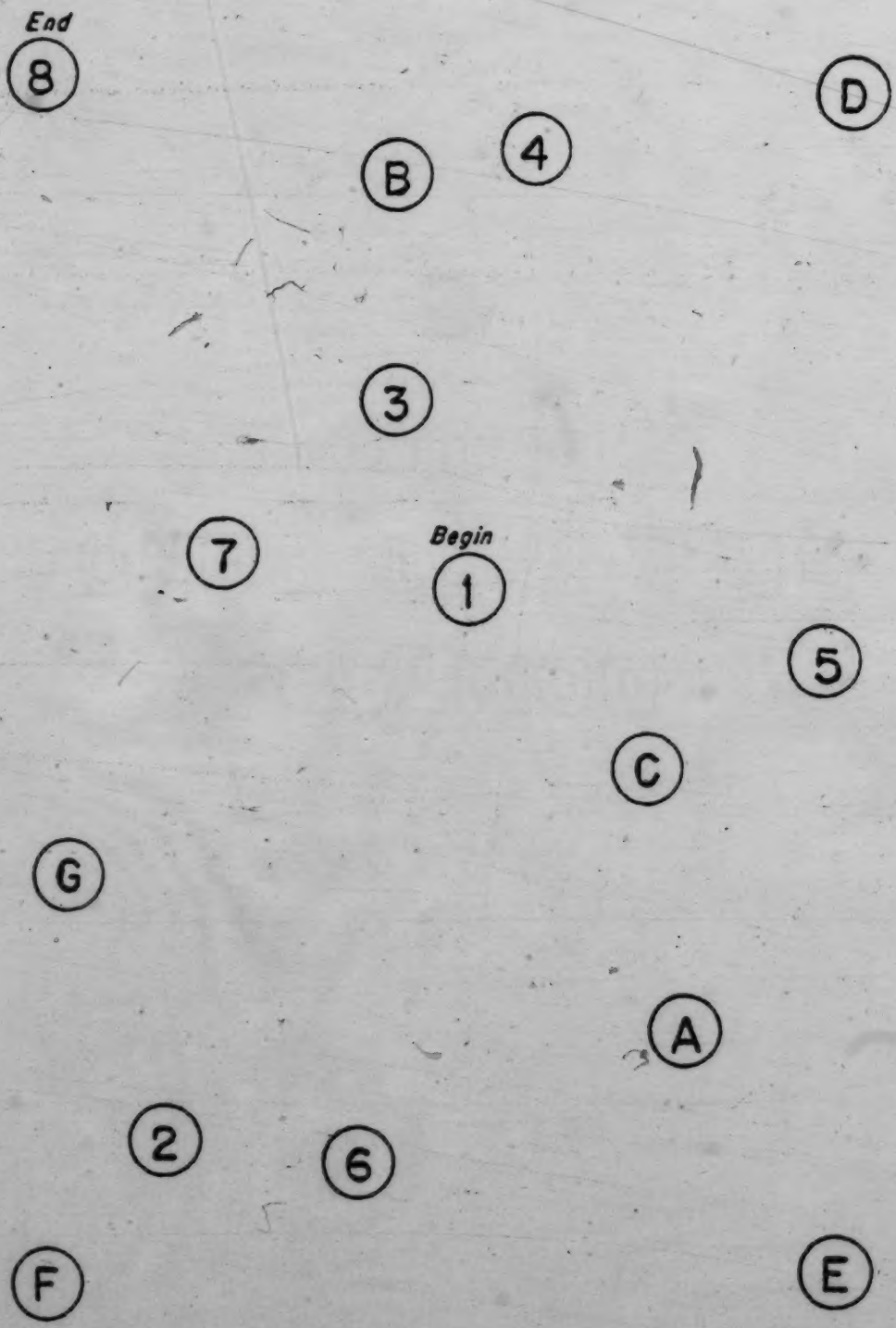
TRAIL MAKING

Part B

SAMPLE

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APPENDIX D

Directions for the Experimental Trial-Making Task

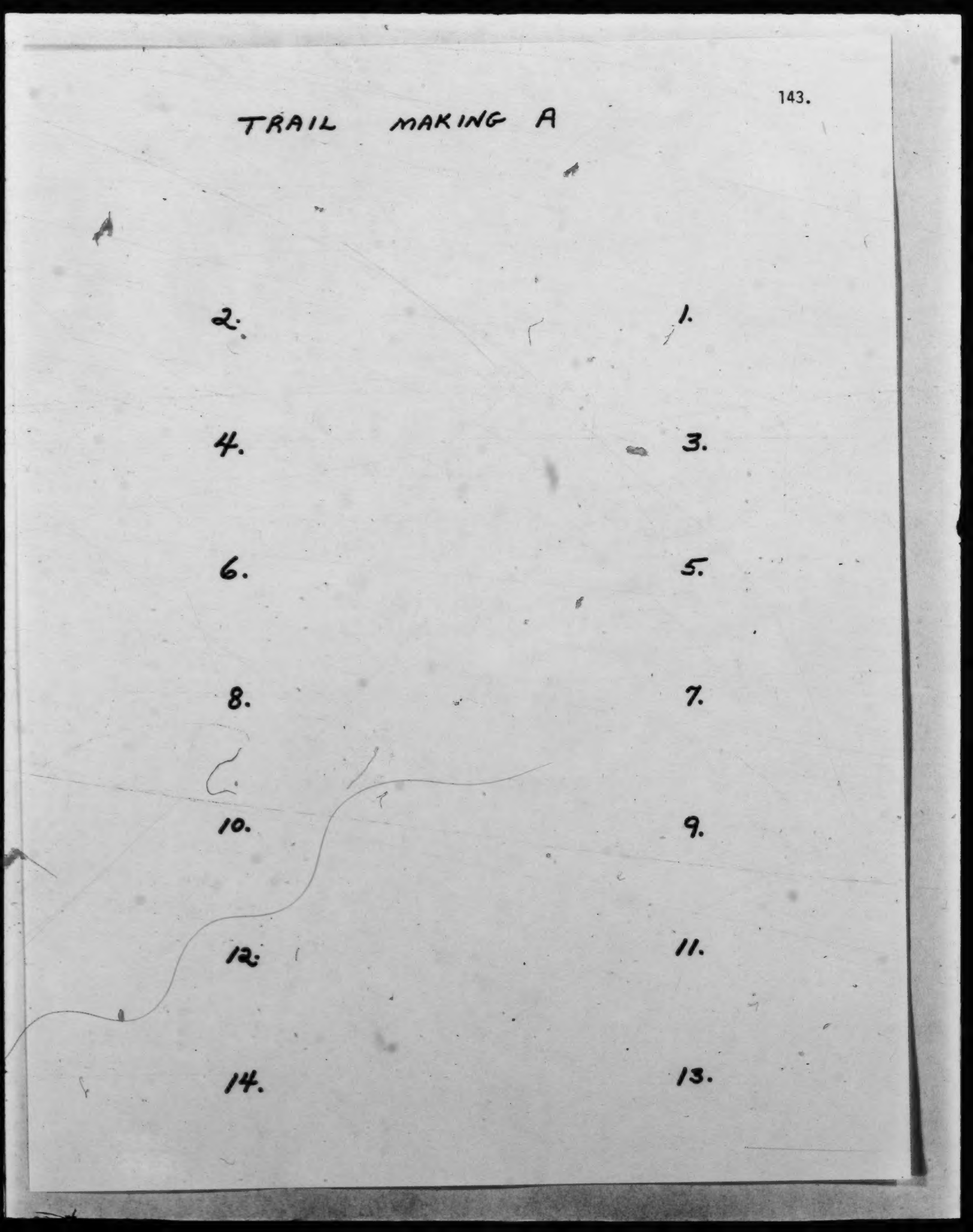
PART A: Experimental

"This part is similar to the others we have done except that there are only numbers in this part of the task. In this test your task is to draw lines between the numbers on the page in the correct order - from 1 to 2, from 2 to 3, from 3 to 4 and so on, until the end is reached. Do it as quickly as possible."

PART B: Experimental

"Here we have another test in which you must join the numbers consecutively, by drawing lines between them in the correct order, that is as if you are counting. Do it as quickly as possible."

TRAIL MAKING A



TRAIL MAKING B

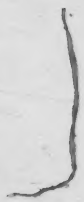


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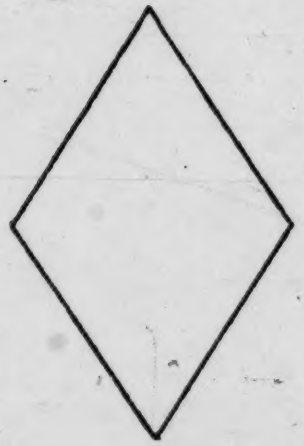
Figure Copying

1.



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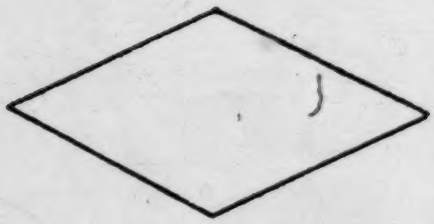

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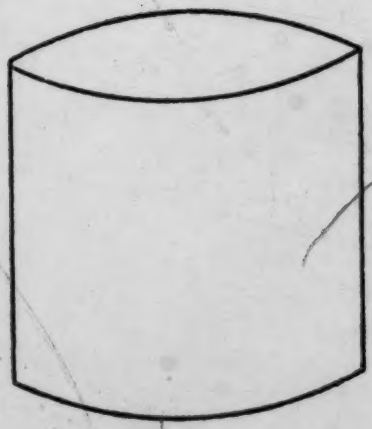

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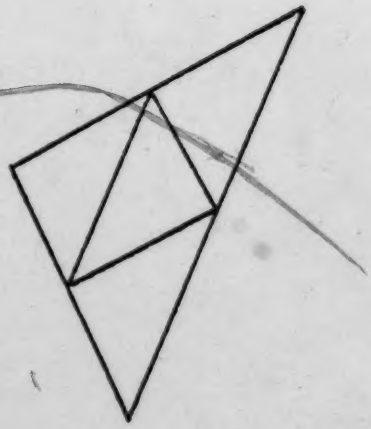

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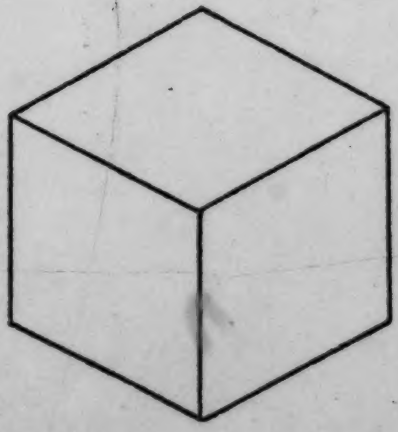

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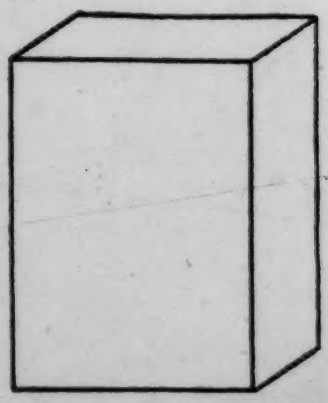

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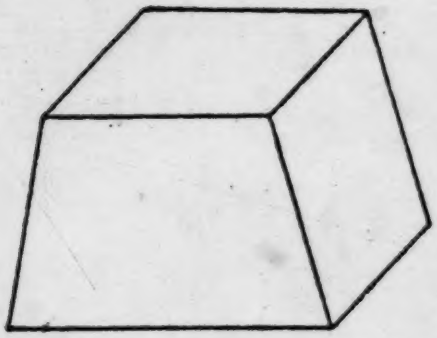

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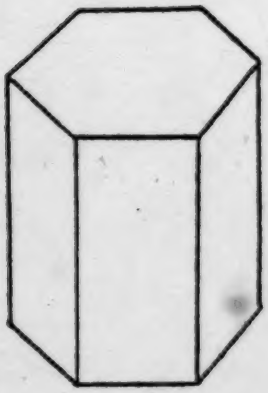

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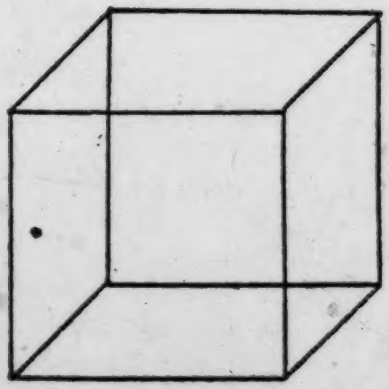

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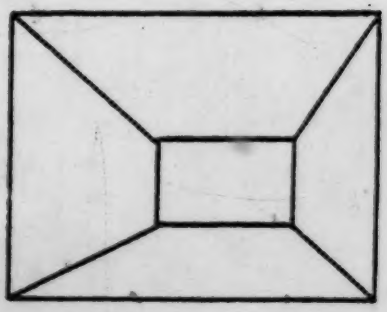
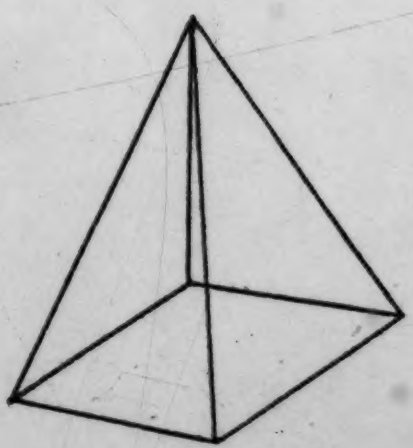


11.



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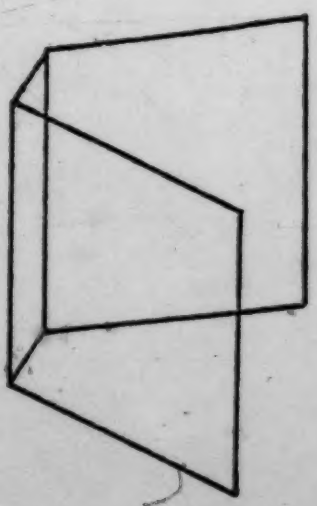


Guidelines for administering and scoring the Figure Copying Test

The subject is required to make an exact, free-hand copy of twelve shapes: a vertical diamond; a horizontal diamond; a cylinder; tilted triangles; a cuboid; an enclosed box; a trapezoid; an octahedron; a necker cube; a tapered box; a pyramid; and a stylized open book. Drawings are scored according to accuracy of shape rather than absolute size. The following principles apply:

For all drawings

1. The drawings must generally maintain the proper perspective.
2. Drawings where applicable should be symmetrical.
3. Angles should not be rounded.
4. Figures should not be rotated.
5. Angles should be equal, when applicable.
6. Slight bowing or irregularity of lines is permitted.
7. Lines should meet approximately, but small gaps or extensions are acceptable.
8. When two attempts are made, the worst is scored.

Scoring principles for individual figures

Scoring of each figure involves some limited flexibility. In general, some principles are considered more important than others and are more stringently enforced. In the following table of standards, criteria are given in order of importance. Where the same numbers are given for two criteria, they are considered equally important.

1. Vertical Diamond
   1. No 'kite' shapes
      1. Horizontal opposing corners
      2. Four good corners
      3. Only slight 'dog-ears' allowed
      4. Both acute angles must be 60^{o} or less

2. Horizontal Diamond
   1. No obvious 'kites'
      1. Opposing corners
      2. Four good corners
   2. Horizontal axis between 170^{o} and 190^{o}
   3. Both acute angles 60^{o} or less

3. Cylinder
   1. Diameters should be approximately equal to the height
   2. Diameters of the base and top should be approximately equal
   2. The base and the top lines should be curved.

4. Tilted Triangles
   1. Two triangles
   2. Right outer side sloped 100^{o} or more
   3. Two corners of inner triangle clearly touch near medians of outer triangle, and the third must be close.
   3. Left outer angle approximately 90^{o}

5. Cuboid

   1. Proper perspective must be preserved as in the specimen
   2. There should be three approximately equal diamonds
   3. All lines should be approximately equal (ie. lengths, widths, and heights)

6. Enclosed Box

   1. Proper perspective must be maintained as in the specimen
   1. Figure must be almost half as high as it is wide
   2. Acute angles of parallelogram should be between 30^{o} and 45^{o}

7. Trapezoid

   1. Proper perspective should be preserved as in the specimen
   2. Parallelograms should have angles of approximately 45^{o}

8. Octahedron

   1. Hexagon should have approximately equal sides
   2. Vertical rectangle should be bounded by two, near equal parallelograms
   3. Left and right extreme angles of the hexagon should be near 90^{o}

9. Necker Cube

   1. Correct number of parts
   1. Correct orientation
   1. No evidence of confusion

10. Tapered Box

   1. No confusion or distortion

2. Inner form clearly shifted to the right and down
3. Outer form a parallelogram
3. Inner form a horizontal rectangle

11. Pyramid

1. Figure is balanced around the vertical
1. No confusion or distortion
2. Base of figure is a diamond
2. All triangles are near isosles

12. Stylized Open Book

1. Two, mirror-image parallelograms with the acute angles near 75^{o}
1. No confusion or distortion
2. Thin parallelogram should have acute angles between 30^{o} and 45^{o}

APPENDIX F

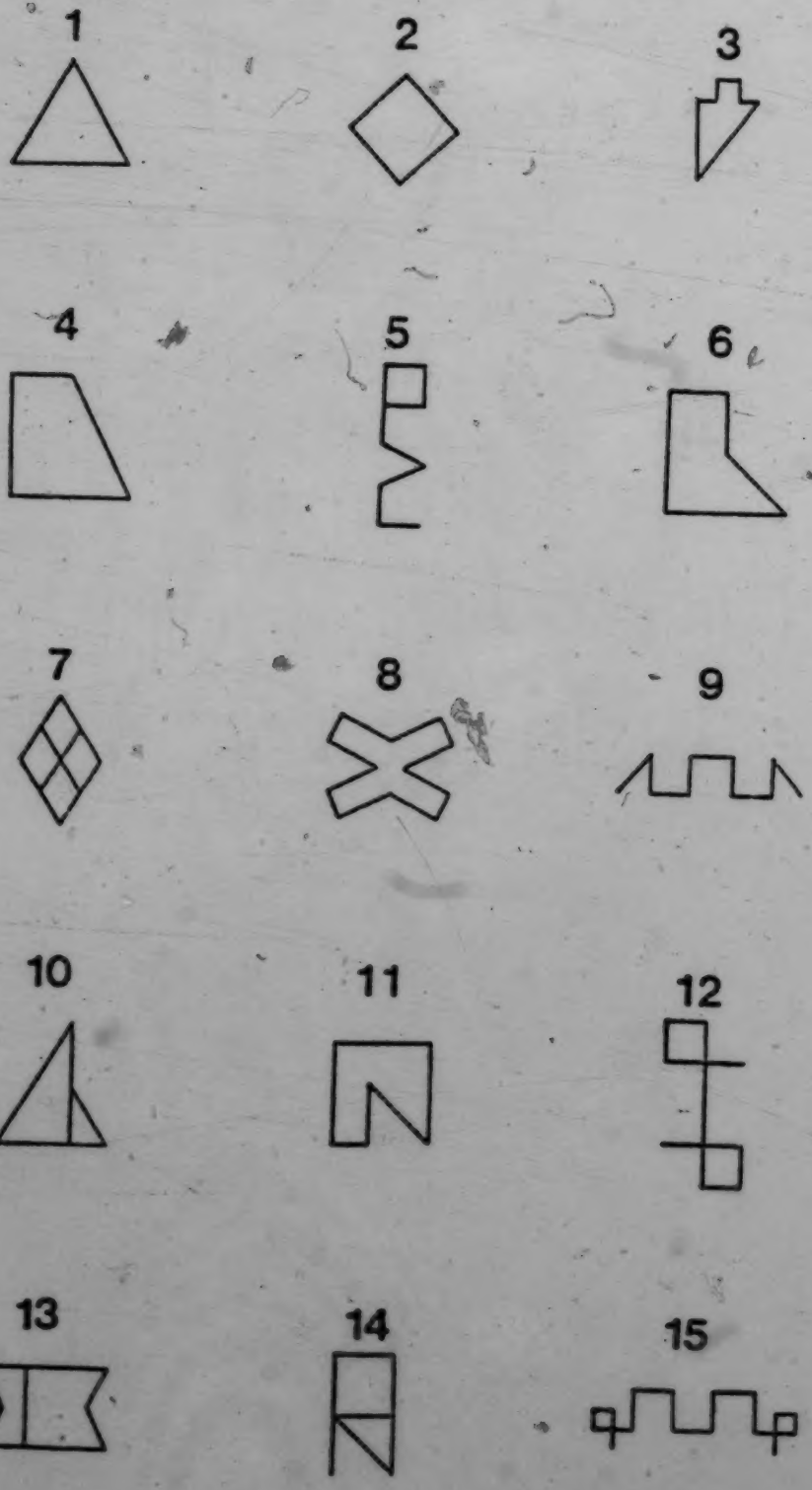
DIGIT SPAN

Name_____ # _____

5-8-2	3
6-9-4	3
6-4-3-9	4
7-2-8-6	4
4-2-7-3-1	5
7-5-8-3-6	5
6-1-9-4-7-3	6
3-9-2-4-8-7	6
5-9-1-7-4-2-8	7
4-1-7-9-3-8-6	7
5-8-1-9-2-6-4-7	8
3-8-2-9-5-1-7-4	8
2-7-5-8-6-2-5-8-4	9
7-1-3-9-4-2-5-6-8	9

APPENDIX G

Memory-for-Design Test (MFD)



APPENDIX H

INSTRUCTIONS

1. Read Statements
2. Solve Problem
3. Is the Conclusion True or False
4. Circle the Correct Answer

For example: Tina is smaller than Sally

Sally is smaller than Ann

Conclusion: Tina is smaller than Ann (True) or False

SHEET I

Time:_____

1. Mary is taller than Sue.
   Sue is taller than Joan.

   Conclusion: Mary is taller than Joan. True or False

2. Ann is shorter than Jane.
   Jane is shorter than Alice.

   Conclusion: Alice is shorter than Ann. True or False

3. Alice is older than Sally.
   Sally is older than Ann.

   Conclusion: Alice is older than Ann. True or False

4. Joan is younger than Susan.
   Susan is younger than Donna.

   Conclusion: Joan is younger than Donna. True or False

5. Betty is taller than Karen.
   Karen is taller than Carla.

   Conclusion: Carla is taller than Betty. True or False

6. Sharon is younger than Cheryl.
   Cheryl is younger than Rita.

   Conclusion: Rita is younger than Sharon. True or False

7. Peggy is older than Ruth.
   Ruth is older than Leanne.

   Conclusion: Peggy is older than Leanne. True or False

8. Marie is shorter than Angela.
   Angela is shorter than Gina.

   Conclusion: Gina is shorter than Marie. True or False

SHEET 2 Time: _____

1. Susan is taller than Ann.
   Jane is taller than Susan.

   Conclusion: Ann is taller than Jane. True or False

2. Frances is shorter than Joan.
   Susan is shorter than Frances.

   Conclusion: Joan is shorter than Susan. True or False

3. Sharon is younger than Mary.
   Leanne is younger than Sharon.

   Conclusion: Leanne is younger than Mary. True or False

4. Norma is older than Alice.
   Karen is older than Norma.

   Conclusion: Karen is older than Alice. True or False

5. Rita is shorter than Janice.
   Sally is shorter than Rita.

   Conclusion: Janice is shorter than Sally. True or False

6. Lily is taller than Ruth.
   Cheryl is taller than Lily.

   Conclusion: Ruth is taller than Cheryl. True or False

7. Allison is younger than Pam.
   Diane is younger than Allison.

   Conclusion: Diane is younger than Pam. True or False

8. Jane is older than Sally.
   Sybil is older than Jane.

   Conclusion: Sybil is older than Sally. True or False

SHEET 3 Time: _____

1. Ann is taller than Alice.
   Susan is shorter than Alice.

   Conclusion: Susan is taller than Ann. True or False

2. Betty is shorter than Gina.
   Sharon is taller than Gina.

   Conclusion: Betty is shorter than Sharon. True or False

3. Marie is younger than Carla.
   Betty is older than Carla.

   Conclusion: Marie is younger than Betty. True or False

4. Cheryl is older than Betty.
   Susan is younger than Betty.

   Conclusion: Cheryl is older than Susan. True or False

5. Norma is taller than Sharon.
   Ruth is shorter than Sharon.

   Conclusion: Ruth is taller than Norma. True or False

6. Ellen is shorter than Susan.
   Alice is taller than Susan.

   Conclusion: Ellen is shorter than Alice. True or False

7. Lily is younger than Susan.
   Pam is older than Susan.

   Conclusion: Pam is younger than Lily. True or False

8. Ann is older than Sarah.
   Becky is younger than Sarah.

   Conclusion: Becky is older than Ann. True or False

SHEET 4 Time: _____

1. Peggy is taller than Susan.
   Peggy is shorter than Becky.

   Conclusion: Susan is taller than Becky. True or False

2. Gina is shorter than Ruth.
   Gina is taller than Leanne.

   Conclusion: Leanne is shorter than Ruth. True or False

3. Carla is older than Diane.
   Carla is younger than Rita.

   Conclusion: Rita is older than Diane. True or False

4. Karen is younger than Susan.
   Karen is older than Anna.

   Conclusion: Anna is younger than Susan. True or False

5. Ann is taller than Susan.
   Ann is shorter than Sally.

   Conclusion: Susan is taller than Sally. True or False

6. Sally is shorter than Pam.
   Sally is taller than Pat.

   Conclusion: Pam is shorter than Pat. True or False

7. Susan is older than Sarah.
   Susan is younger than Joan.

   Conclusion: Sarah is older than Joan. True or False

8. Margaret is younger than Pam.
   Margaret is older than Sally.

   Conclusion: Pam is younger than Sally. True or False

APPENDIX I

Directions for the Mastermind Task

Testing Procedure

The directions to each subject were played on a cassette tape recorder, and were as follows:

"This is a game which involves problem solving. There are six colour coded pegs in this game, they are: blue, brown, yellow, red, green and orange. In each game I will choose four different colours out of the six. I will place these coloured pegs into holes which are shielded from your vision. You will not be able to see them.

Your task is to try to duplicate the exact colours I have chosen, and their exact position, by placing them into the board. You may choose any four of the six coloured pegs, in each row. One important thing you must remember is that the colours I have chosen all differ from one another, so no two colours are the same.

After you have placed the four coloured pegs into the board, I will tell you whether the pegs you have chosen are correct in colour and whether the pegs were in the right position. If your peg matches the one I have chosen in colour, but is not in the correct position, I will put a white peg into the key peg holes adjacent to your row. If your coloured peg matches the one I have chosen in it's colour and is also in the correct position, I will put a black peg into the key peg hole. If you choose a colour which does not match the colour I have chosen, the key peg holes adjacent to your row will be left empty. This will tell you that the colours you have chosen are not correct.

Let me review the instructions for you. Your job in this game is to duplicate the coloured coded pegs and their positions which I have chosen. When you duplicate it, I will place four black key pegs adjacent to your row of pegs. This will indicate to you, that you have matched the exact colours

and positions of the code I have chosen.

Are there any questions before we begin? Also if you have any questions during the game please don't hesitate to ask me.

Experimenter Colour Codes

Trial 1 - brown, yellow, red, green

Trial 2 - green, orange, red, blue

Trial 3 - orange, red, yellow, green

APPENDIX J

Table 26

Study One: Factor Correlations after Oblique Rotation of Marker Tests (n=50)

Variable	Simultaneous	Successive
Simultaneous	1.0000	.14071
Successive	.14701	1.0000

Table 27

Study Two: Means and Standard Deviations of Visual Search Experiment for Top and Bottom Quartile Groups (in Secs.) (n=28)

VARIABLE	MEAN	STANDARD DEVIATION
Group		
Top - Trial 1	3.30	1.33
Trial 2	1.84	.47
Trial 3	1.62	.38
Trial 4	1.57	.50
Bottom- Trial 1	8.46	3.20
Trial 2	5.18	1.52
Trial 3	6.07	2.88
Trial 4	4.06	2.06